# COMPUTER GRAPHICS WORLD

INNOVATION IN VISUAL COMPUTING
November 1999

## Play It Again, Woody

Pixar adds depth to Toy Story 2

## Toying with CAD

## Iron Giant's Ten-Ton Toon

## Visualizing Uncertainty

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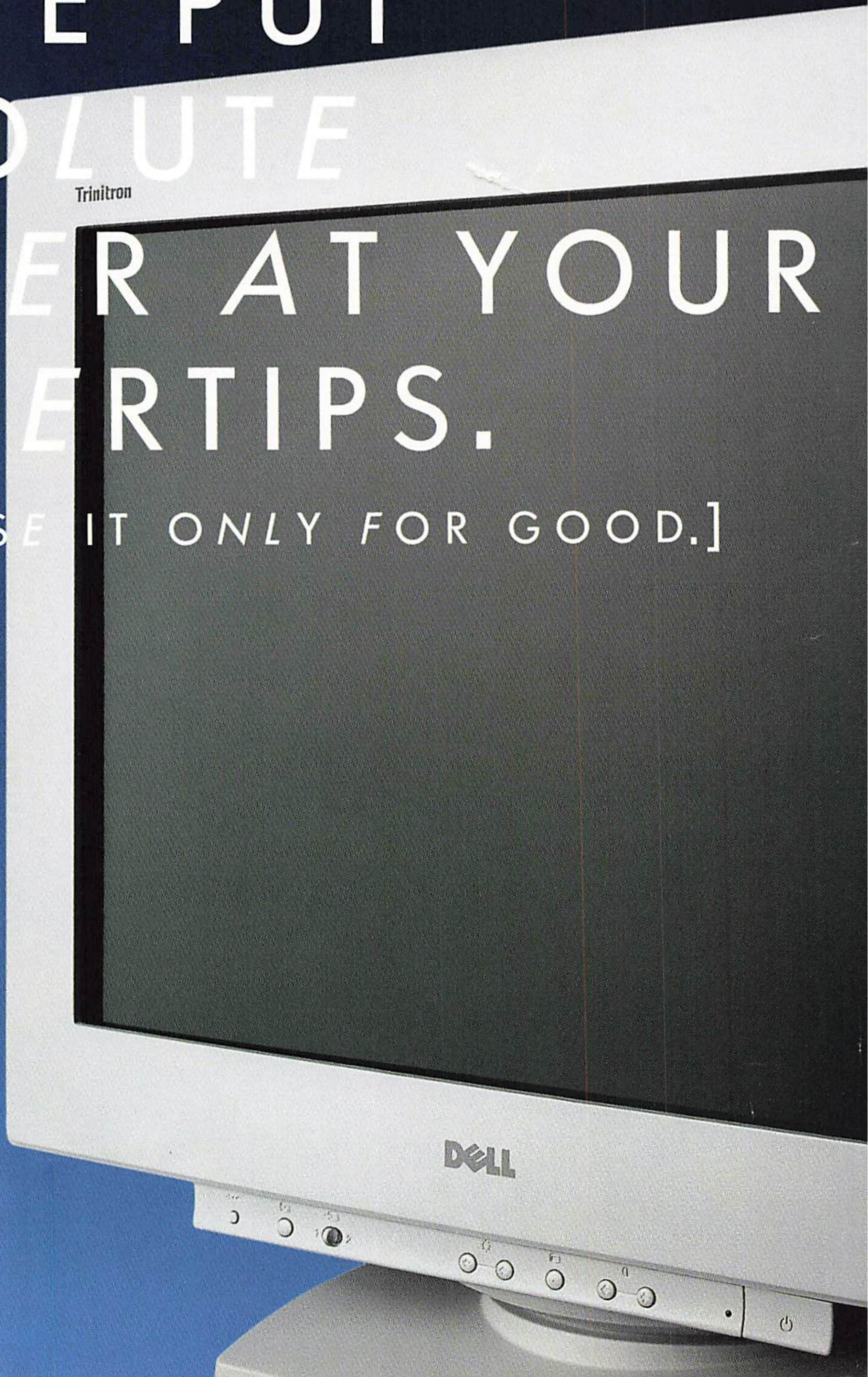

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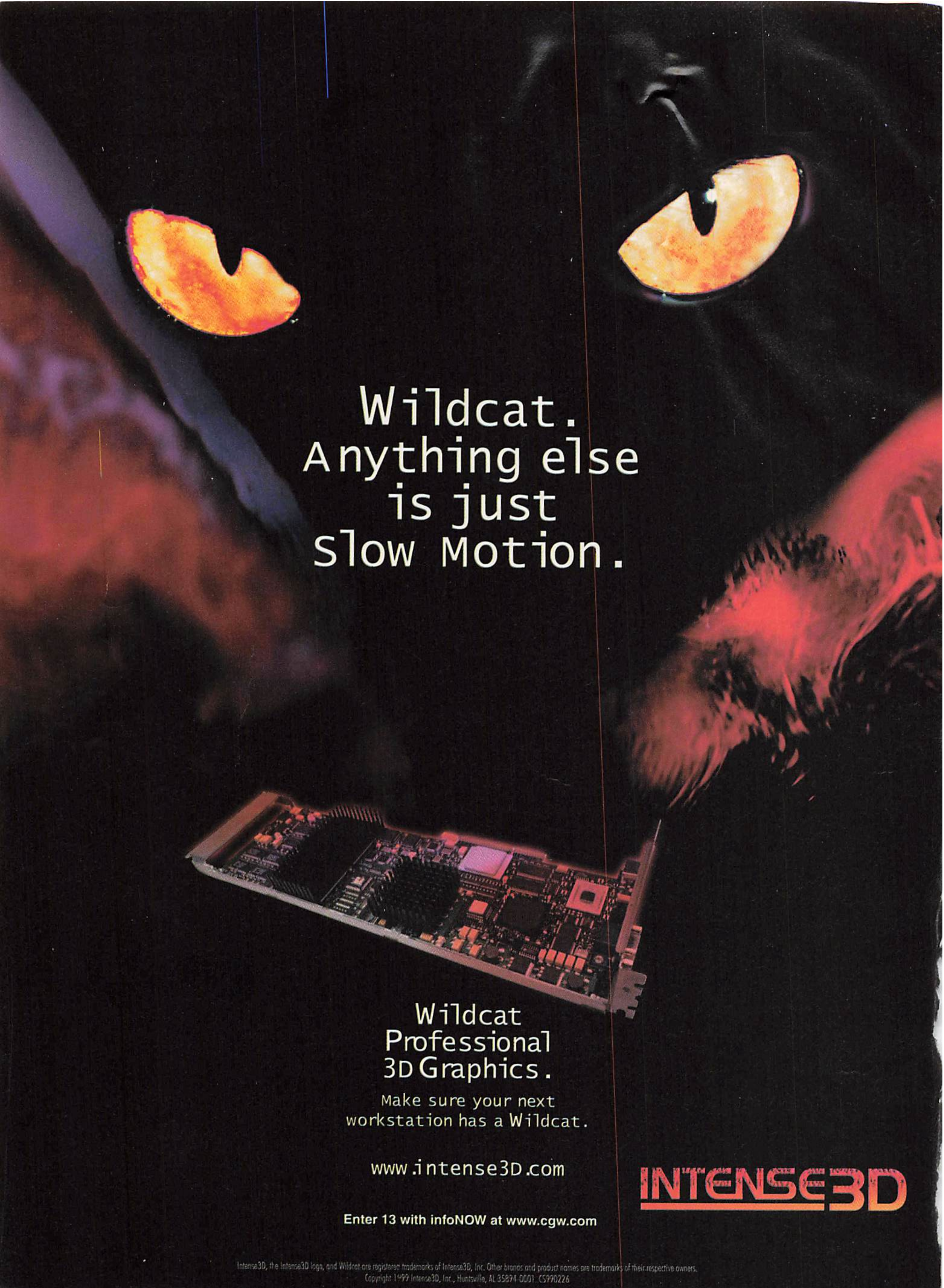

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Volume 22, Number 11
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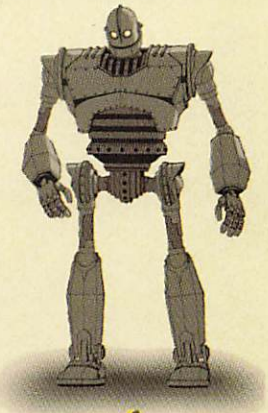
• *By Barbara Robertson*



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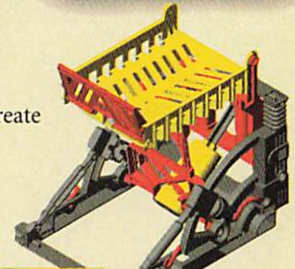

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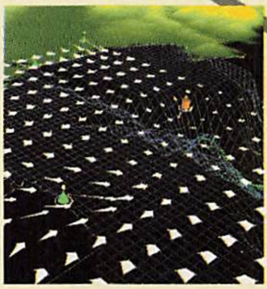

**ON THE COVER**

One of the greatest challenges for the creators of *Toy Story 2* was taking advantage of the latest modeling and rendering techniques to enhance the characters and their environments while still retaining the basic look of the 1995 original film. For more about the making of the movie, see page 27.

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EDITOR'S NOTE

# The New Frontier

In her February 1999 feature, "Sim-Factory," contributing editor Caren Potter concluded that software for simulating production processes may eventually—like CAD—become a tool no manufacturing company can compete without. Well, that prediction may come to pass sooner than expected, if the number of factory-simulation product introductions by vendors at the recent Computer Technology Solutions (CTS) exhibition, formerly known as Autofact, is any indication.

Perhaps the most sweeping announcement came from Engineering Animation Inc. (EAI). Long known for high-end visualization and, more recently, its innovative VisFactory plant-design program, EAI launched Open Virtual Factory, a framework containing modules for simulating a company's entire manufacturing operation. Similarly, rival Tecnomatix, with roots in manufacturing engineering, added 3D programs for designing work cells, machine operations, and assembly lines to its all-encompassing Digital Factory environment.

Other factory-simulation vendors introduced upgrades, as well. Lanner enhanced the visualization features of Witness, its discrete-event analysis software, to automatically transform 2D simulations into 3D VR-like animations. And Adept Technology followed suit with Production Pilot, an interactive 3D virtual-factory package. Beyond these announcements, CAD/CAM vendors also weighed in with 3D visualization tools for manufacturing. A case in point is Unigraphics Solutions, which incorporated a new 3D press-line simulation module into its Unigraphics Version 16 release.

Why the sudden burst of virtual-manufacturing offerings at a show that has historically focused more on CAD than CAM? One reason is that vendors recognize CAM as the new frontier. "Some design engineers are moving from 2D to 3D CAD, and others are moving from high-end Unix to mid-range NT CAD, but everyone is fighting each other for these customers," says Kenneth Versprille, CAD/CAM market analyst at D.H. Brown Associates. CAM, on the other hand, is the "developing competitive battlefield," he contends. "It's at a point now where solid modeling was 15 years ago, but it has the potential to be as big as, if not bigger than, the product-design market."

Of course, for this kind of growth to occur, the supply of manufacturing tools must be matched by a demand for them. So far, few manufacturers have made the leap toward creating computer simulations of their whole operations. This is understandable, given that the systems for doing so are new and that the challenges of adapting them to a company's particular methods are huge. Thus, the best strategy is to start by modeling pieces of the process and to pick projects that are more forgiving in terms of scheduling, says Patrice Romzick, manager of market research at CIMdata. Small successes, she says, can then be propagated throughout the organization. In fact, vendors point to a number of early adopters who have achieved big production-cycle reductions by focusing on self-contained pilot projects and technology demonstrations.

The other challenge—for users and vendors, alike—will be to link these tools back to CAD systems so product designers can be sure that manufacturing will be able to efficiently build in the unique features they create. After all, the ultimate goal is not simply to reduce time to market. Rather, it's to get there first with innovative products.

Phil LoPiccolo

Phil LoPiccolo: Editor-in-Chief

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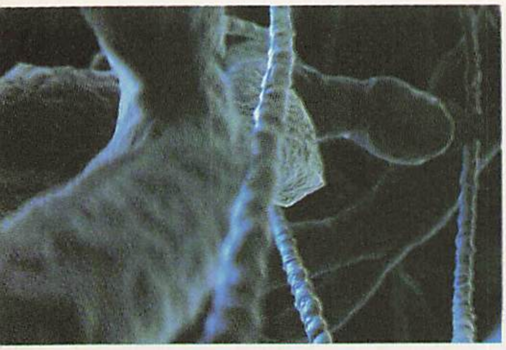
## Fight Club Effects

I enjoyed your August 1999 article on special effects in current movies ("Summer Heat," pg. 43). Similar capsule reviews of effects in movies at least several times a year would be an excellent idea for your publication.

With regard to the movie *Fight Club,* I wanted to point out that two other CG vendors worked on the film, BUF and Image Savant. I'm convinced that both companies did extraordinary work on this film. I executed the closing-scene animation almost entirely by myself, and the shots were delivered by Gray Matter, which did the compositing under the supervision of Kevin Haug.



*Fight Club* promises to be the most controversial movie of the year because of both its narrative and its visual content. This film employs visual effects in some extremely unorthodox ways and in the direct service of the story and feeling of the film. I am very proud to have been a part of this production, and I would like to see everyone who worked so hard on it get equal time.

Richard "Dr." Baily
*Image Savant*
*Hollywood, CA*

## Editor's Reply:

*For various reasons—but primarily because our August 1999 story ran far in advance of* Fight Club's *release date and thus limited the amount of information we could divulge—we focused on one extremely technical scene in the film. Though, as you've pointed out, the movie has many other CG scenes produced by different effects houses, the brain fly-through was our focus for that issue. This kind of shot hadn't been attempted before, and the innovative aspect, plus the emphasis on scientific accuracy, made this effect of particular interest to us.*

## Star Wars: Overwhelmed by FX?

I was interested to read your August 1999 Editor's Note ("The Stars of Star Wars," pg. 5) about the special effects used in *Star Wars Episode One: The Phantom Menace.* Initially, I agreed with the responses of the various people interviewed for the article, but then a thought occurred to me: While I was watching the film, like everyone else, I found myself saying, "Wow, these are incredible computer graphics." And in my opinion, that's a problem.

Special effects shouldn't be measured by how much better they are than the ones that have been done before, but by how closely they are able to mirror reality. Even though the graphics in *Phantom Menace* are excellent, and extremely detailed, they still look like computer graphics. If filmmakers want us to be completely immersed in a movie, we shouldn't be able to tell that the effects are effects at all.

Granted, this is almost impossible. But many of the effects in *Phantom Menace* could have been done, and probably done better, using more traditional sorts of techniques. A film that I think looked more realistic than most was *Jurassic Park.* The computer graphics were not overpowering in this movie, and the ones that were used looked very realistic. Most of the effects shots were done with dark lighting and other atmospheric techniques that enhanced the realism.

Another approach is to make a movie so good that people don't concentrate on the effects. In the original *Star Wars* film, the number of effects shots was limited, most of the alien worlds were restricted to earthly-looking sets, and even the planet Tatooine had much less alien life than it did in the later *Phantom Menace.* But I'm sure everyone will agree that in almost every way the first was a more effective film.

Yes, all four *Star Wars* movies have glitches. For instance, the bar scene in the first installment of the series included many unrealistic-looking aliens, but the story was so well done that nobody cared. Maybe George Lucas can take a hint from that success and change the focus of *Episode Two.* Hopefully the effects will be better, or the film will involve the audience so much that the effects don't matter. I, for one, am hoping for a better story line.

Allen Strickland
*Saratoga, CA*

## Inspiration

I just thought I'd write to tell you that I enjoyed the August issue of *Computer Graphics World* very much. There are times when I want to throw my G3 against the wall and forget about all this graphics stuff, but your magazine has a way of inspiring and keeping me in the saddle. In truth, creating and manipulating 3D and photographic images is way too much fun to give up. Looks like I'm hooked for life.

Ron Pfister
*Prince George,*
*British Columbia*
*Canada*

### We Value Your Input

We welcome any insights you may have that would further our readers' understanding of topics discussed in this issue. We may edit your response to conform to our style and space requirements.
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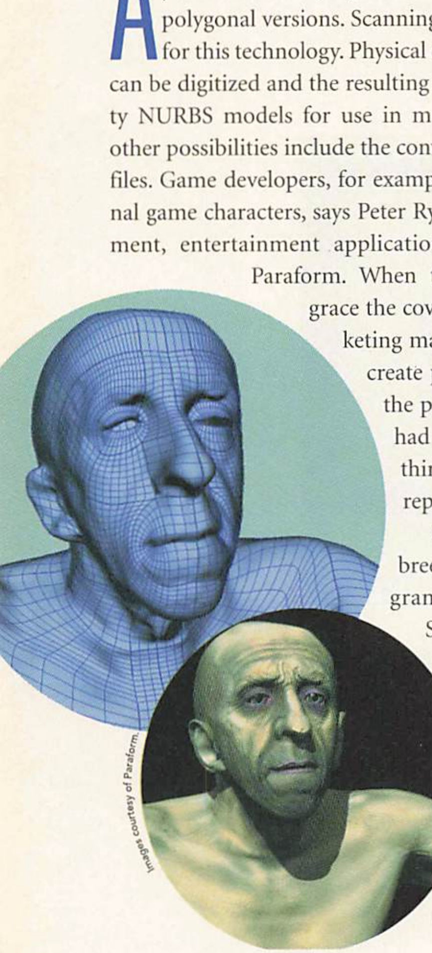
# Polygons-to-NURBS Products Proliferate

A new family of computer graphics products has emerged this year—software programs that create NURBS models from polygonal versions. Scanning is the most obvious application for this technology. Physical objects, including human beings, can be digitized and the resulting images converted to high-density NURBS models for use in manufacturing or animation. But other possibilities include the conversion of pre-existing polygonal files. Game developers, for example, maintain libraries of polygonal game characters, says Peter Ryce, director of product management, entertainment applications, for the software company Paraform. When these characters are needed to grace the covers of boxes, magazines, or marketing materials, Paraform can be used to create print-quality NURBS models. In the past, says Ryce, "These companies had to farm out the NURBS work to third parties, who might not even represent the characters correctly."


Images courtesy of Paraform.

Paraform is just one of the new breed of polygons-to-NURBS programs. Others include geomagic Studio from Raindrop Geomagic, CySlice 2.0 from the Australian company headus, and EM 3.0 from InSpeck, a maker of optical digitizers. Each of these products has an emphasis and capabilities slightly different from the other—Studio's main area is CAD, while Paraform, CySlice, and EM target the entertainment industries. But the goal of each program is the same: to make NURBS models quicker and easier to produce.

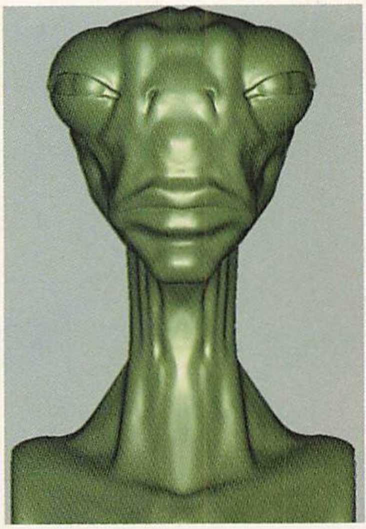


Image courtesy Raindrop Geomagic and Sensable Technologies.

Geomagic Studio is a $19,995 program suite (consisting of the company's Wrap and Shape applications) that stands out for its speedy and automatic NURBS model creation. Users do not have to create cross-sections or patches, because Shape does it for them. In addition, the Wrap program automatically converts point-cloud data from scans to polygonal models. In a non-scanning application, Raindrop Geomagic recently teamed with Sensable Technologies (Cambridge, MA) to create a NURBS model of an alien's head (above) that was sculpted on-screen in Sensable's Freeform modeling system, then converted to NURBS using Shape.

A recent addition to the entertainment arena is the $15,000 Paraform program, which debuted at Siggraph this year, though it underwent extensive field tests beforehand. (Paraform was used, for example, to create the giant crocodile in the movie *Lake Placid.*) Though not automatic like geomagic Studio, Paraform's manually defined path layout and parametrization control offer users a high level of choice—a plus for experienced NURBS modelers who may wish to assign different levels of detail to their models.

In comparing the two programs, California-based industry analyst Wanda Meloni says, "Paraform's manual process allows users a

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News

## Benchmark Results for Graphics Workstations

Beginning with this issue, *Computer Graphics World* will provide highlights from current SPEC/GPC benchmark listings. The Standard Performance Evaluation Corp./Graphics Performance Characterization Group is part of a nonprofit corporation that creates and maintains a standardized set of benchmarks for high-performance computing. The graphics-oriented GPC tests include SPECviewperf, SPECapc for Pro/Engineer, and a variety of other application-specific benchmarks.

The tests are performed on a semimonthly basis by participating vendors on their own

### Top 10 Scores for the Lightscape Viewset of SPECviewperf 6.1.1

| COMPANY AND WORKSTATION | GRAPHICS CARD | MEAN SCORE |
|---|---|---|
| Hewlett-Packard J5000 | HP Visualize fx6 Pro | 4.17 |
| Hewlett-Packard C3000 | HP Visualize fx4 Pro | 4.06 |
| Hewlett-Packard C3000 | HP Visualize fx6 Pro | 4.01 |
| Intergraph TDZ2000 GX1 550MHz | Intense 3D Wildcat 4105 | 3.50 |
| Siemens Celsius 620 | Celsius Wildcat 4105 | 3.47 |
| Intergraph Zx1 600MHz | Intense 3D Wildcat 4105 | 3.46 |
| Dell Precision WorkStation 410 600MHz | Intense3D Pro Wildcat 4000 | 3.44 |
| Fujitsu FMV-Pro 8550T2 Model 3D+ | Intergraph Intense 3D Wildcat 4000 | 3.34 |
| Compaq Professional Workstation AP500 | Powerstorm 600 | 3.33 |
| Hewlett-Packard B1000 | HP Visualize fx4 Pro | 3.20 |

Largest mean score represents best performance. Companies listed are voluntary participants.
Source: SPEC/GPC benchmark results October 1999. Copyright Standard Performance Evaluation Corporation.

great deal of flexibility. Raindrop Geomagic's Shape is quick and easy to use because it's automatic. It's a real time-saver."

At $4000, CySlice 2.0 is a cost-effective polygons-to-NURBS solution from headus, a software developer and service bureau for Cyberware (Monterey, CA) scanners. Six years ago, headus began to develop programs to edit and produce NURBS models from Cyberware scans. Today, CySlice is a stand-alone product that can be used with any polygonal data, whether from scans or libraries. According to headus principal Jill Smith, CySlice's surfacing tools have been designed for animators. That said, "We also have many customers who use the tools in CySlice to help them build surfaces in CAD packages."

Polygons-to-NURBS products can also be found as editing tools sold with high-end digitizers, similar to the way CySlice began. One example is EM 3.0 from InSpeck. This 3D package allows users to create models by merging the different views captured by the company's digitizers. A recent addition to the product is the ability to generate a single-patch or multi-patch textured NURBS surface.

EM is sold bundled with InSpeck's optical digitizers or as a $6000 stand-alone. It requires Windows 95/98/NT and 64MB of RAM. geomagic Studio requires Windows/95/98/NT and 128MB of RAM. An SGI IRIX version is also available. Paraform runs under Windows NT and requires 256MB of RAM; an SGI IRIX version is under development. CySlice runs under NT or SGI IRIX and requires 128MB of RAM. *—Jenny Donelan*

Paraform; Santa Clara, CA; 408-855-4300;
www.paraform.com **infoNOW 63**

Raindrop Geomagic; Research Triangle Park, NC;
800-251-5551; www.geomagic.com **infoNOW 64**

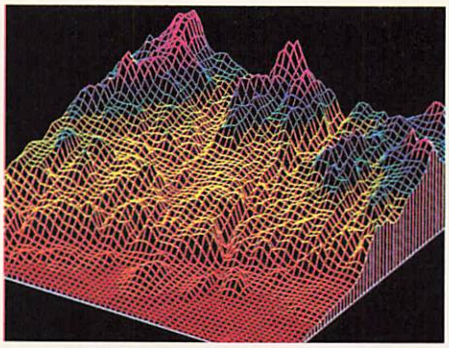
headus; Perth, Australia; 61-8-9444-4648;
www.headus.com.au **infoNOW 65**

InSpeck EM 3.0; Quebec City, Canada; 514-284-1101);
www.inspeck.com **infoNOW 66**

## More 3D Maps with Surfer 7

In 1985, Golden Software introduced Surfer, a program designed to help users transform raw data into more visually appealing and easily understood digital maps. Fourteen years later, the venerable contouring and 3D surface-mapping program is in its seventh incarnation, and is now capable of transforming XYZ data into vector maps as well as contour, wireframe, image, shaded relief, base, and post types. New gridding filters in Surfer 7 allow users to more accurately grid XYZ data, and to easily exclude unwanted or duplicate data when creating grid files. Variogram modeling, which helps spatially assess data, is another addition, as is a new geologic fault-line option.

Surfer users include engineers, biologists, climatologists, medical researchers, and geologists. David Holley, a consulting geologist based in Abilene, Texas, and an early user of Surfer 7, has been employing it to prepare presentations for geologic projects. Holley particularly likes Surfer's new faulting option, which allows him to input a fault line directly into maps. "With Surfer 6," he says, "I had to simulate faulting, which was very time consuming."



Surfer 7 costs $599 and is available directly from Golden Software. To run, it requires Windows 95/98/NT and a minimum of 12MB of RAM, (Golden Software; Golden, CO; 800-972-1021; www.goldensoftware.com) *—JD*
**infoNOW 67**

machines, according to guidelines provided by SPEC/GPC, and are subject to peer review by other vendors belonging to SPEC/GPC. The benchmarks are available to all users and can be downloaded free of charge from the organization's Web site.

This month, we list the 10 workstations that received the best ratings for the Lightscape (a lighting design and rendering program) viewset of the SPECviewperf 6.1.1 benchmark. The Lightscape viewset consists of walk-throughs in four differently rendered Lightscape environments. The mean scores at left represent the combined, weighted results of the four tests, measured in the number of frames per second the machines were able to execute. The larger the number, therefore, the better the performance.

To see how the same workstations fared in different benchmark tests and to view results from additional workstations, visit SPEC/GPC's Web site at www.spec.org/gpc.

## In Brief

**Microsoft Corp.** (Redmond, WA) has agreed to acquire business diagramming and technical drawing software manufacturer **Visio Corp.** (Seattle) in a transaction valued at approximately $1.3 billion....**Muse Technologies** (Albuquerque, NM), a developer of perceptual computing products, will acquire **Virtual Presence Ltd.** (London, England), a maker of interactive 3D systems, in a transaction expected to close before the end of the year. Muse has also announced the formation of a subsidiary that will focus on government business operations. The new **Muse Federal Systems** will operate out of both Albuquerque and Alexandria, Virginia....Mechanical CAD developer **Baystate Technologies** (Marlborough, MA) is now operating under the name **CADKEY Corporation**. Baystate acquired the CADKEY product line three years ago and is assuming the new name because of that product's high visibility, according to company spokespersons....**SDRC** (Cincinnati) has acquired **Enterprise Software Products** (Exton, PA), a developer of finite-element modeling software.

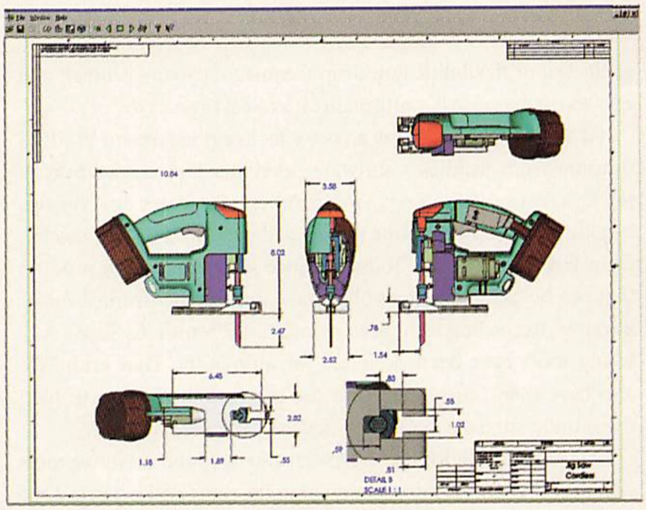
*—Jenny Donelan*

## SolidWorks Communicates with eDrawings

While 3D solid modeling is certainly a better way to communicate design information," says Rick Chin, manager of eDrawings for SolidWorks, "many people are more comfortable in the 2D environment they were trained in." In an effort to explore the needs of that group—primarily small-to midsize manufacturing companies—SolidWorks has introduced eDrawings, a new kind of compressed electronic drawing file with built-in intelligence.

By pushing the Publish button on a menu bar, a user of SolidWorks, AutoCAD, or any CAD system outputting a DXF or DWG file can create an electronic version of an on-screen drawing that is small enough (less than 1MB) to send via e-mail, and viewable to any recipient running Windows, thanks to a compact (250K) viewer embedded in each file. Once open, the eDrawing offers virtual folding, which allows users to see and arrange several drawing views at a time; hyperlinking, with selected views of the drawing according to where a user points and clicks; a 3D pointer; and animation.

EDrawings resulted from a random telephone survey of manufacturers. "What came through with the most emotion," says Chin, "was the difficulty of communicating with others outside the company." Due to incompatible CAD file formats, many companies don't send electronic files to each other, says Chin, relying instead on faxes and overnight packages. Even the recent influx of CAD viewers hasn't helped much, as the files are usually large.



EDrawings will not only help 2D CAD operations work more efficiently, it will help bridge the information gap between 2D and 3D. The program will be available in the fourth quarter of 1999, free for a limited time.

(SolidWorks Corp.; Concord, MA; 800-693-9000; www.solidworks.com) *—JD*

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## For People Who Need People

The latest product from human-simulation company Boston Dynamics Inc. (BDI) is destined to be a crowd-pleaser, or at least a crowd-maker. Called PeopleShop, the turnkey application lets users rapidly populate real-time virtual environments with lifelike human characters who move realistically throughout the digital terrain in which they're placed. The system comes with a full cast of people, each of whom has its own skeleton, texture-mapped geometry, and behavior library. The characters are embedded with a degree of intelligence, enabling them to move realistically within and around structures and objects and to make natural transitions between activities.

Most of the PeopleShop functions can be accessed in real time from within a scene. Users can create and edit activity via a graphical interface and watch the characters act out their rolls immediately. Also, they can edit and play a scene simultaneously. The program supports embeddable run-time applications, enabling users to export PeopleShop scenes and install them into third-party real-time systems.

PeopleShop is an outgrowth of BDI's research into real-time character development and biomechanical simulations. The application was designed to streamline the creation of virtual environments for a range of applications, including architectural visualization, urban planning, marketing, driving simulation, military training, and mission-planning systems.

"[PeopleShop] is really the first off-the-shelf, reasonably priced program for this kind of thing," says Ron Wolff, a researcher at the Naval Air Warfare Center Training Systems Division (NAWCTSD). Wolff and his colleagues use modeling and simulation tools to help evaluate new weapon concepts. They populate their virtual environments with armed soldiers who need to move and respond to the environment. "There's a lot of work going on in human animation, but much of it is still very complex and far off. BDI has taken a simplistic approach to provide a product that works now," says Wolff.

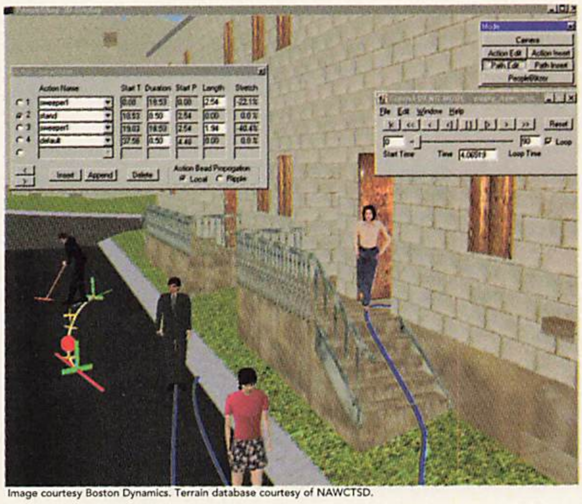

Image courtesy Boston Dynamics. Terrain database courtesy of NAWCTSD.

BDI sells PeopleShop direct in North America and through resellers internationally. Direct, the development software, including all characters and motions, costs $13,500. (Boston Dynamics; Cambridge, MA; 617-868-5600; www.bdi.com) *—Diana Mahoney*

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# An Impressive Spread

## Scientists get a new perspective on massive datasets with a spreadsheet-based visualization and analysis tool

DIANA PHILLIPS MAHONEY

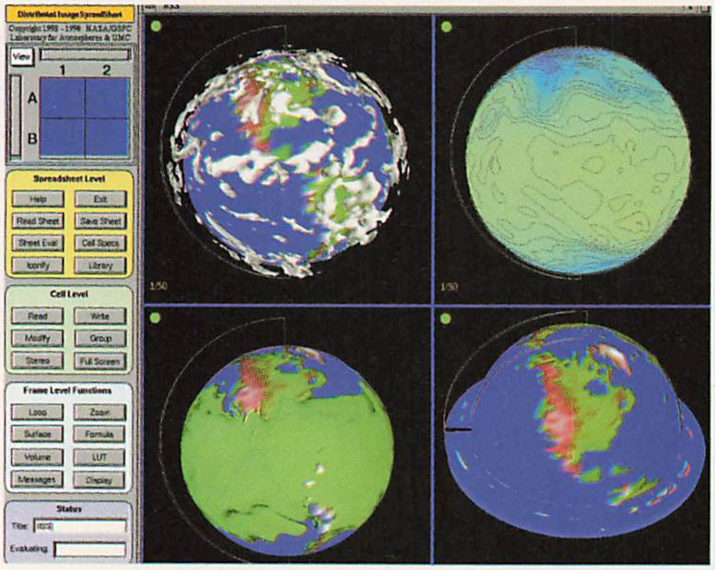
So many pictures, so few ways to fully appreciate them. This could easily be the slogan of scientists using computer visualization to better understand the world we live in. While dramatic increases in the power of graphics workstations and visualization software over the past few years have provided unmatched perspectives on complex scientific data, simultaneous advances in data-acquisition and simulation techniques have resulted in volumes of information so large that they're often unwieldy.

"It's very common for individual scientists to be working with gigabyte-size datasets, and to quickly run out of even 400 to 500 GB of disk space," says Kannappan Palaniappan, a computer scientist at the University of Missouri at Columbia. "And the problem will only get bigger. By next year, we'll be talking in terms of terabytes of data." In the earth sciences arena, for example, NASA's Earth Observing System (EOS) satellites are expected to produce between 1 and 2 terabytes of data per day. "When you have that much information," says Palaniappan, "traditional ways of accessing it, looking at it, and trying to understand complex relationships within it are insufficient."

In an effort to help scientists make the most of these large volumes of data, Palaniappan, together with Fritz Hasler of the NASA Goddard Space Flight Center, developed a novel visualization and analysis tool that combines advanced visualization, image processing, algorithm development, and data-archiving capabilities with the data-organization and accessibility benefits of a traditional spreadsheet program. Called the Distributed Image SpreadSheet (DISS), the application provides a framework through which researchers can access, view, manipulate, and analyze data that has been retrieved from multiple remote locations and delivered to their desktop workstations via high-performance networks.

DISS runs on SGI workstations and uses SGI's OpenGL for image rendering. The application imports image data from various sources (2D satellite data, 3D model data, numerical simulations, and time-varying datasets) and organizes it into a 2D matrix of cells arranged into rows and columns, which are displayed onscreen in a grid-like interface.

Each cell comprises a series of frames containing individual, related datasets. For example, for a 3D spatial dataset such as a numerical weather-prediction model, each cell might represent one time step of the numerical simulation. At each XYZ location at a given time step, there might be measurements of any number of variables, such as windspeed, pressure, temperature, humidity, and so forth. The representative image data for each of these measurements would be placed in a frame within the cell. The image spreadsheet can contain any number of cells and frames.



**The frames in this Distributed Image Spreadsheet cell offer different perspectives on a global weather prediction model, which scientists can use to make visual and quantitative comparisons.**

DISS supports many image file formats, including JPEG, GIF, and TIFF, as well as many earth science formats. Once the data is input into the spreadsheet framework, there are a number of options for interaction and display. Researchers can visually represent and investigate their data using such techniques as streamlines, cutting planes, trajectories, wind vectors, and orthogonal planes. They can also animate frames within a cell, scroll and zoom within a frame, probe the original data values of the frame, and render the surface data. Additionally, they can link subsets of cells together to compare and manipulate data across multiple related cells. "The cells can be grouped and coordinated synchronously, so if you rotate the data by 30 degrees in one cell, for example, that same operation will be duplicated in all the cells of the group," says Palaniappan.

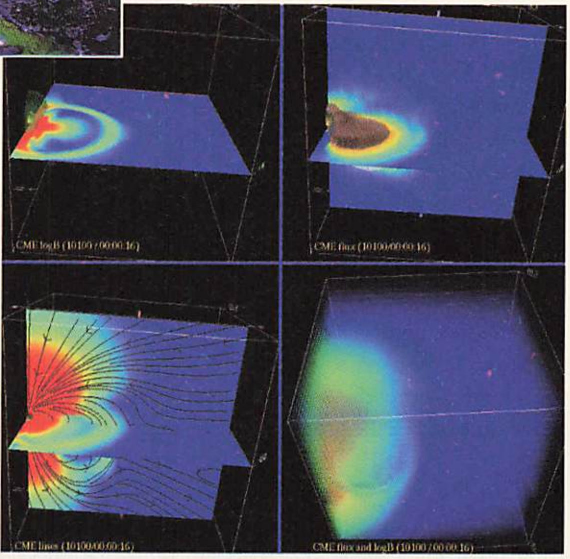
### Seeing Pictures, Running Numbers

DISS is unique in that it lets scientists produce images and run calculations within the same environment, providing more flexibility than traditional visualization tools with respect to the types of questions that can be answered. Palaniappan uses a deforestation application being tested as part of a NASA grant to illustrate this. "Say we're looking at Landsat data for Missouri over the past 20 years. We've got one annual image for every year, 20 images in one cell. We can look through that dataset and make pure visual comparisons, but we can also make quantitative distinctions." For example, he says, "We might want to identify specific areas that have changed over the years. To do this, we can calculate the differences between, say, 1980 and 1981, and 1981 and 1982, and so forth. We can show the differences between the pairs of images in another cell, as a function of the application."

The resulting comparative images will depict the pixelized differences between the pairs, and thus might be "noisy." The user can then fine-tune the information with one of a number of built-in image processing tools. "To identify areas of significant change, you might do some sort of thresholding, or better still you might classify the data into land-cover categories and then look at the percent change in, say, forest cover or in crop land," says Palaniappan.

The DISS technology can also be used to assess the performance of various simulation and visualization algorithms with respect to large volumes of data. "In one of the applications, we compared more than 30 different algorithms for estimating global rainfall over several years to evaluate how well the algorithms were performing," says Palaniappan. Each algorithm was placed in a cell containing a sequence of frames for monthly global precipitation and related variables. "By doing this, we could select subsets of the data and look at the performance differences over a particular region or time period."

**Researchers can use DISS to study environmental and scientific phenomena. A composite view of 1992's Hurricane Andrew is shown above as a time-lapse image based on satellite data. At right are views from four separate time steps of a solar physics simulation.**


CME logB (10100 / 00:00:16)
CME flux (10100/00:00:16)
CME lines (10100/00:00:16)
CME flux and logB (10100 / 00:00:16)

DISS is still considered a prototype application. Its continued development depends in large part on the success of ongoing efforts to improve and implement high-performance networking technologies, such as the government's Next Generation Internet initiative, to support the distributed collection and storage of massive amounts of data.

While the infrastructure for these high-performance networks is in place, not all of the promised features have been standardized, and this affects the applications designed to run on them. For example, says Palaniappan, one important area of research relates to ATM (Asynchronous Transfer Mode) networks and the establishment of quality-of-service protocols. "If my application needs a dedicated bandwidth of 60MB per second, and I'm sharing this with many other people across a network, how is my application guaranteed to get what it needs? There are methods in place for optimizing interactive performance over the network to assure consistent quality, but the network layer protocols and the way a given application should be configured to request such features is not yet standardized," says Palaniappan. "The same is true for multicasting [the transmission of multimedia data to several sites simultaneously]. Standards have to be established for working with large datasets over high-bandwidth networks and for implementing the novel features of these networks."

While waiting for the networking issues to be resolved, Palaniappan and his colleagues are continually enhancing DISS. Currently, the researchers are focusing on further developing the collaborative capabilities through the integration of more intuitive interfaces. "We're looking at things like speech and gesture technologies for interacting with complex data, and we're looking at non-traditional displays such as the Immersive Workbench [SGI/Fakespace]," says Palaniappan. "Our goal is to ease collaboration among different groups at different locations, to help them investigate complex data, such as hurricane dynamics, in an intuitive manner."

The researchers are also working to develop richer algorithms for exploratory data analysis. "We'd like to be able to take any type of large dataset, such as biomedical and financial information, and provide new ways to extract information from it," says Palaniappan. "Consider the National Library of Medicine's Visible Human project. Physicians want to segment that data into anatomically significant regions, which is a classification or clustering task. We'd like to then incorporate knowledge-discovery tools into this same environment."

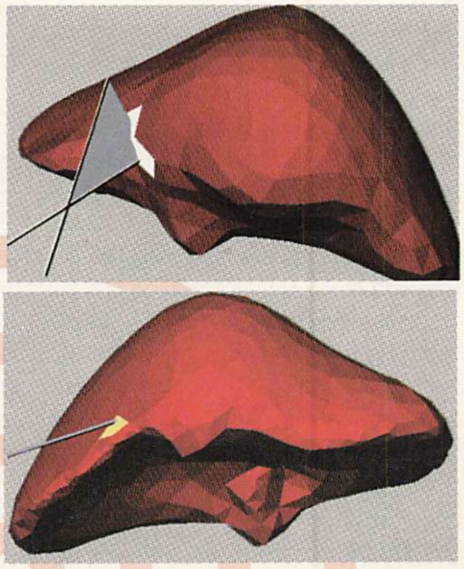
Real-time satellite data processing is another area of focus. "One of the first satellites in NASA's EOS series will have an instrument on board called MODIS, which is a hyperspectral 36-channel imager for measuring various atmosphere, ocean, and land parameters. A group of researchers from various universities is working with NASA support to set up real-time access to that data. Typically, getting useful images from this type of information requires processing it, correcting it, calibrating it, and so forth. We want to be able to produce a quick-look product for real-time operational use, such as in the case of severe weather or forest fires or flooding." The spreadsheet, he says, would serve as a visualization front end for collecting data from the different sites. The distributed computing resources would facilitate the rapid calibration, registration, modification, and visualization of the data.

Future plans include porting DISS to other platforms and making it available commercially or as shareware. "Right now, it's still a research tool that we make available to individual research groups," says Palaniappan. "Eventually, we'll make it more portable for broader distribution."

*Diana Phillips Mahoney is chief technology editor of* Computer Graphics World.

## It's a Hit

Real-time collision detection brings virtual surgery closer to reality



**A virtual laparoscope collides with a deformable liver model. The interaction and subsequent deformation is processed and represented in real time using a hardware-based collision-detection method.**

There's no question that virtual reality has come a long way since its inception more than a decade ago. The digital worlds through which users move are more sophisticated, thanks to advanced modeling, animation, and rendering tools, and innovations in positional tracking and haptic interfaces have resulted in more natural interaction with virtual objects. Additionally, the compute engines driving these developments are getting more powerful by the day.

VR's journey from nascent concept to practical technology is far from complete, however. There are many roadblocks yet to overcome before the technology makes good on many of the promises set forth by early visionaries. This is particularly evident in the area of surgical simulation. While virtual surgery has the potential to fundamentally change the teaching and practice of medicine, doing so requires more from the technology than current tools are able to provide.

To be useful, a surgical simulation has to meet an almost impossibly high standard—the one set by Mother Nature, who did not design human anatomy so that it could be easily mimicked via geometric primitives and standard animation and interaction techniques. To be effective, a surgical simulation must not only realistically reproduce the complexity of human organs, but it must also represent the visual and haptic impact of each and every interaction with the digital objects. And it must do so in real time. Because of the computational intensity of this task, one or more of the critical design factors—real-time operation, photorealistic rendering, or accurate haptic simulation—must often be sacrificed for the sake of another, making the overall experience less-than-real.

A new technique developed by a group of French researchers may bring the technology one step closer to fulfilling its potential. Marie-Paule Cani of the National Polytechnic Institute of Grenoble (INPG), along with Christophe Lombardo and Fabrice Neyret, researchers with iMAGIS (a joint project between the French National Scientific Research Center, INPG, and the Gravir-Imag Lab of the University Joseph Fourier), have developed a hardware-based solution for performing real-time collision detection, one of the most imposing obstacles in surgical simulation.

Accurate, real-time collision detection is an important element of all VR applications, and a critical one to virtual surgery. If a system can't detect and process collisions, synthetic objects will move through each other when in motion rather than react to interference with each other, precluding both useful interaction and a sense of realism. Simulating collision detection is computationally expensive, however. It requires testing for intersections between each pair of virtual objects in a scene, as well as in self-collisions between different parts of the same object. Typically, objects are described using polygonal meshes, and algorithms detect the points at which the faces of the meshes collide. The more objects, or faces of objects, that collide, the more demanding the algorithm.

In addition to calculating the visual impact of such collisions, surgical simulations require computing the haptic response as well. "In surgery simulators, the user trains for surgical gestures on virtual models of the human body by interacting with a moving tool. He or she needs to be able to feel as well as see the objects the tool is colliding with," says Cani. This increases the processing load of the simulation by an

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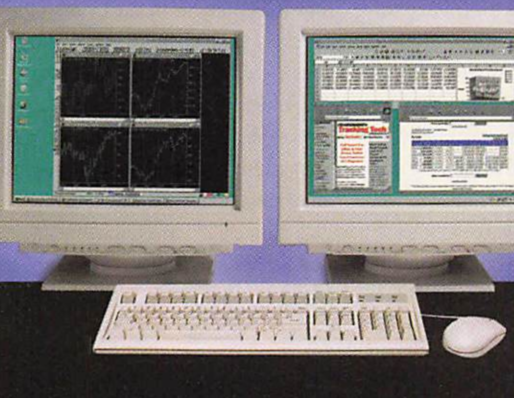

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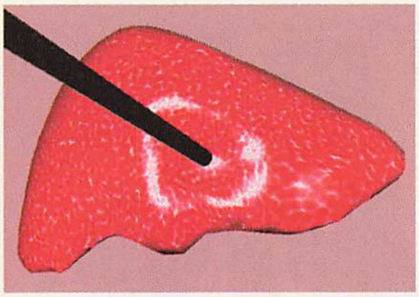
order of magnitude, because the human haptic response is far more sensitive than the visual one, requiring 500 calculations per second to simulate reality, as opposed to 25 or 30 for a realistic visual response.

Another, more subtle problem developers must contend with is that time in the world of computers is discrete. An object can be in front of an obstacle at one time step and behind it at the next, while never actually "colliding" with it. This occurs when the virtual objects are thin or when the motions are quick. As a result, the system needs to be able to test for collisions "in the meantime" between two steps. "Strictly speaking, this means [the system] is no longer testing for collisions between pairs of faces, but between moving faces, or prisms in a 4D space," says Cani. Once again, this significantly adds to the computational burden.



To test for collisions between a surgical tool and the virtual liver, the graphics hardware provides a list of faces in the organ intersected by the tool.

Although there have been a number of developments in the area of collision detection in the past few years, most standard approaches are ill suited to virtual surgery applications, primarily because human organs are non-convex and they deform over time. For example, one "family" of solutions relies on specific data structures that store the closest points and faces for each pair of moving objects. These methods exploit temporal coherence, in that the stored features vary only slightly at each time step. This approach is only useful, however, when dealing with convex-shaped objects, however. For non-convex objects (those with boundaries not described by outward curves), there are locations where the closest points change suddenly, even for a slight location change.

Another approach involves precomputing hierarchies of oriented bounding volumes (spheres, boxes, or grids) that tightly fit the geometry of the virtual objects. The volumes perform efficient rejection tests to determine if a given series of computations will be useful before implementing the simulation. In applications in which the virtual objects deform over time, the hierarchy has to be recomputed at each time step, considerably impacting the performance of the simulation.

The approach the French researchers have taken avoids these pitfalls. Rather than trying to make some of the existing software-based geometric and algorithmic optimization methods "fit" the difficult surgical simulation problem, the team uses a hardware solution to simulate real-time interaction between virtual objects and rigid, geometrically simple tools. With respect to surgical simulation, the researchers' efforts focus on laparoscopic surgery—a type of minimally invasive procedure in which a camera-tipped probe and surgical instruments are inserted into a patient through small incisions. The surgeon manipulates the devices based on views captured by the probe and delivered to an adjacent video monitor. This type of procedure is well suited to virtual representation because of its monitor-based paradigm and the limited range of motion of the surgical tools. In this case, the laparoscope also fits the bill in terms of being a rigid tool that is defined by a simple geometry.

## A New Approach

"The method the researchers have developed relies on an analogy between collision detection and the first part of a traditional projective rendering process," says Cani. The collision-detection process—testing for intersections by finding object faces that penetrate each other—is similar to the use of clipping planes in rendering, whereby faces of objects are clipped toward a viewing volume, characterized by the location, orientation, and projection of a camera. This is done before projection and rasterization as a way to render only the intersection between the objects in the scene and the viewing volume, and it is a function that is handled well by specialized graphics hardware.

The researchers borrowed this model to achieve accurate, real-time collision detection. The first step is to specify a viewing volume that corresponds to the shape of the tool or to the volume covered by the tool between consecutive time steps, and use hardware to "render" the main object relative to the "camera," says Cani. "We can get the hardware to provide a feedback buffer containing the list of faces intersected by the tool. If nothing is visible, then there is no collision."

The advantage of this approach is twofold. First, it detects collisions between the tool and arbitrarily complex objects without the need for precomputation, so objects can deform over time without any loss of performance. Second, because the tool trajectory between time steps can be modeled as a viewing volume, the resulting collision detection is highly accurate, again without increasing the computational load.

This collision-detection method is simple to program, notes Cani, requiring only a dozen lines of code in any OpenGL application with appropriate 3D graphics acceleration capabilities. Additionally, the method is portable, thanks to the availability of OpenGL on many architectures, and is "open" in that it can use any geometric primitive (such as NURBS) that is treated by the graphics library. In principle, the method will work with other graphics libraries, such as Direct3D, as long as the graphics card accelerates the geometric portion of the rendering process as well as the rasterization component.

To demonstrate the efficacy of their hardware-based collision-detection process, the researchers have developed a virtual liver model that deforms in real-time based on the action of the surgical tool. The user interacts with the organ using SensAble Technology's Phantom force-feedback device. The researchers are currently extending the simulation to handle incisions made into the liver so that, as with "the real thing," the simulated organ undergoes significant deformations and topological changes as parts of it are cut and removed. Cani expects to have a version of the system in the hands of surgeons within one year for evaluation.

*Diana Phillips Mahoney is chief technology editor of* Computer Graphics World.

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# The Science of Art

I once spoke to a group of would-be animators at the Toronto Animation Festival. At the end of my talk, someone asked me if I thought mathematics had a place in the studies of an aspiring digital artist. I replied that math had given me no small advantage in my occupation, and that because of my ability to generate solutions as well as enact them, I had never lacked for work or compensation. My answer so enraged a teacher of digital animation at one of the local schools that he stood up and shouted that I was wrong, that digital artistry had nothing whatsoever to do with mathematics.

A still from the animation "SkyWhales," created by Caleb Howard and Kevin Mack, shows overlapping volume functions for the clouds and islands in the sky.

This man's rage illustrates the superstitious revulsion some digital artists hold toward mathematics and technology, even as they embrace them in their daily work. However, I would contend that a great deal of the art of digital imagery is bound to an understanding of the language and tools of mathematics. Yes, it is possible to do a good job and to earn respect in the field of digital effects without having a deep understanding of the tools one wields. But artists who gain the greatest recognition, by creating previously unattempted effects, invariably have learned that they must know the deeper mechanisms of their tool sets. Just as sculptors must learn the structure and character of the rock they hew, and ceramicists must learn the chemistry of glaze pigmentation to push forward their creative expressions, so too must those who work with pixels and computers really understand the algorithms that lie at the heart of their medium. And they must be able to develop new mechanisms and techniques if they are to be innovative artists. Those who don't may remain craftspeople—destined to recreate effects designed by those with deeper understanding of the medium.

**Just as sculptors must know the structure of the rock they hew, so must digital artists understand the algorithms of their computers**

## BY CALEB HOWARD

A look at my own experience may support my argument: I have been working as a digital artist in Los Angeles since 1993, on such films as *Apollo 13, True Lies,* and more recently, *Star Trek: Insurrection,* and *Mystery Men.* I came to the industry with a degree in mathematics from the University of Waterloo in Canada. In school, I was never particularly talented in the traditional creative media, such as clay or paint. The computer was different, however, and in it I found a mathematician's palette.

Since discovering the potential of visual computing, I have developed from a mathematical and technical background into what I am now—an artist. I have learned much artistry from my classically trained coworkers, and I am grateful for their assistance in my continuing development. What I have needed to learn of art has been facilitated greatly by the understanding I already had of mathematics. Having come to an understanding of both aspects of the job, I now believe that I use math far more each day than I use artistry.

Digital artists all utilize mathematics, whether they are aware of it or not. Unfortunately, many don't understand the nature of the tools they employ. More digital artists could use a little math in their backgrounds—just as more mathematicians should be encouraged to explore their creative visual tendencies on the computer. And in defense of those with a greater affinity for math than for art, I say that they should not necessarily be relegated to the mere support of digital artistry, which sometimes happens. I have also worked in this capacity, and it is the folly of the industry that such positions are greatly underappreciated—financially as well as creatively.

I know digital artists more talented than I, and programmers and mathematicians who are more proficient. Still, in an industry that has seen many cutbacks, I continue to have my pick of work because of my mixed training. My math and software background, coupled with my ongoing artistic development, has given me a rare and useful role, bridging the conceptual and communication gap that exists between those who understand the parlance of technology and those who understand the language of art.

*Caleb Howard is R&D/digital effects supervisor at Rhythm and Hues Studios in Los Angeles. He has also worked at Digital Domain (Los Angeles), BIG animation (Toronto), Topix (Toronto), Square (Los Angeles; Honolulu), and VIFX (Los Angeles).*

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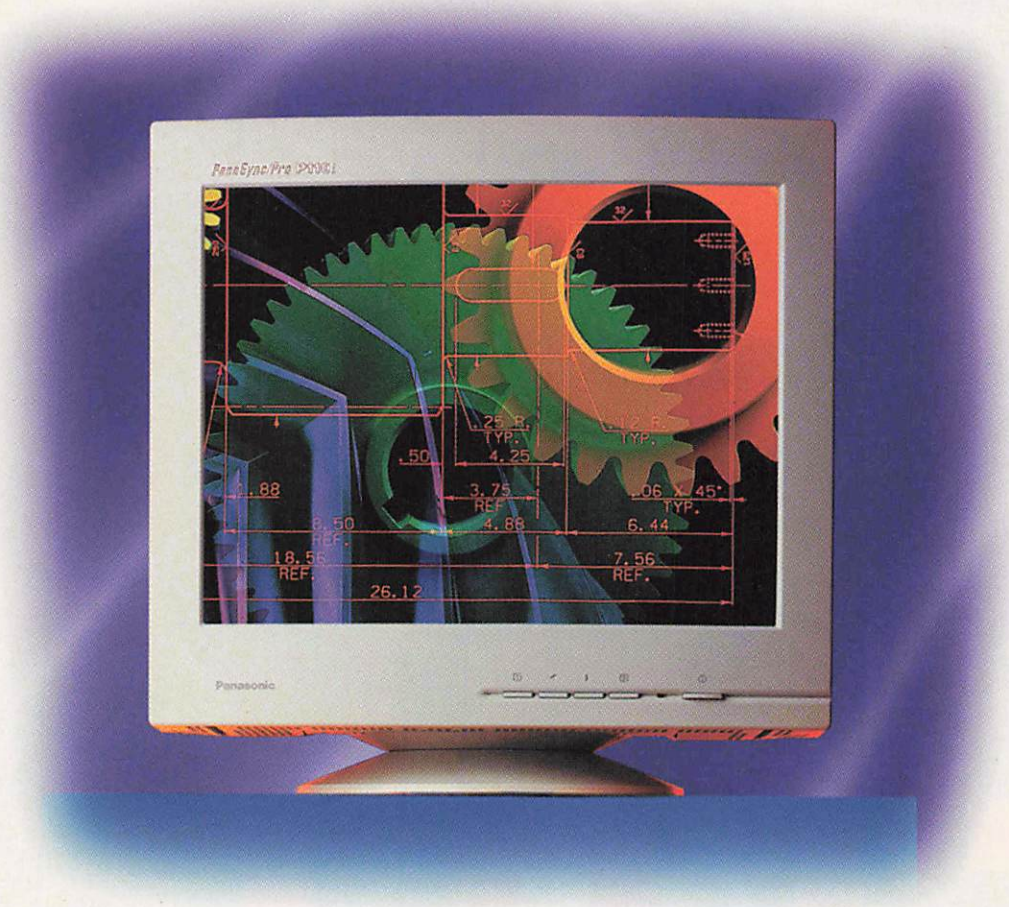

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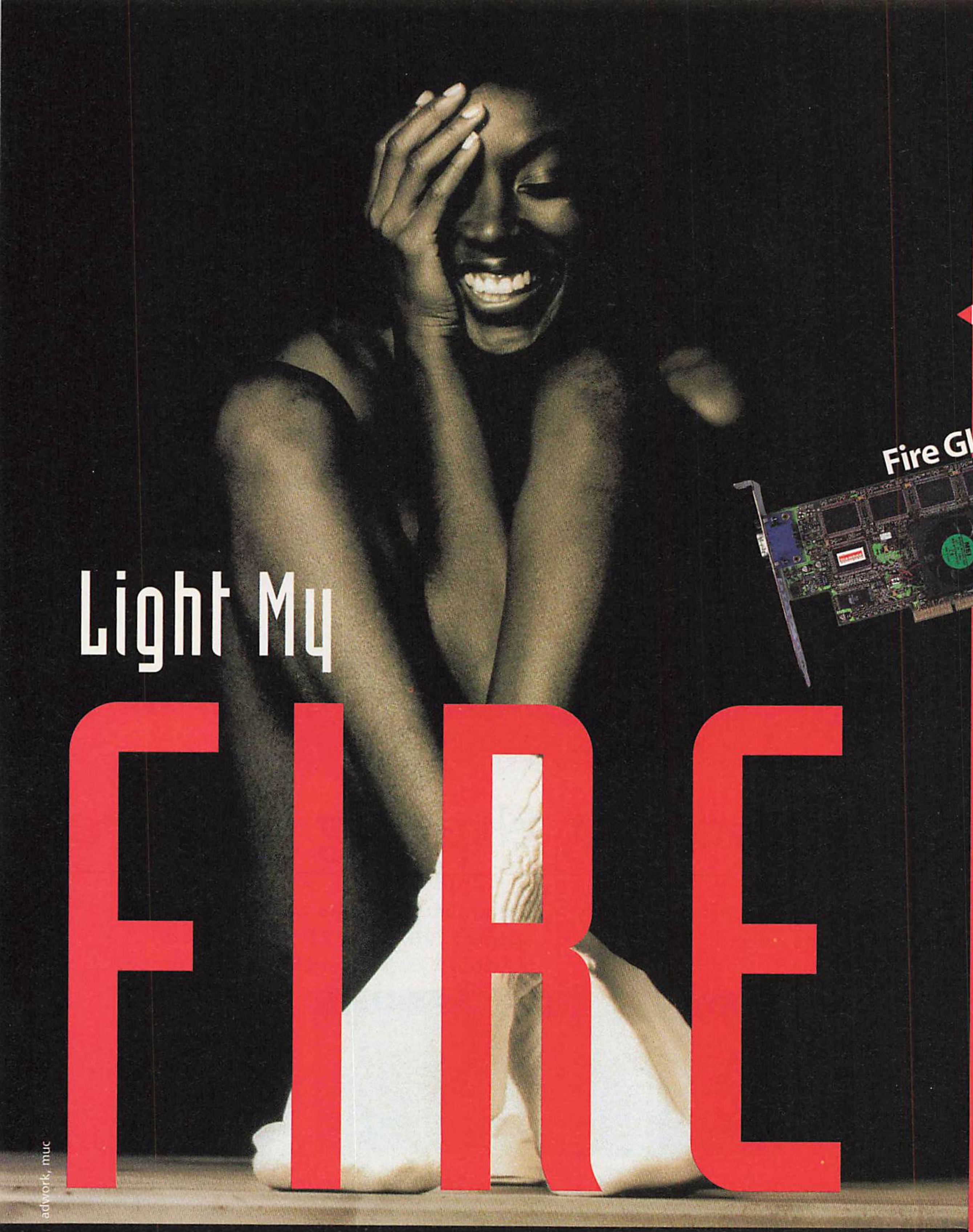

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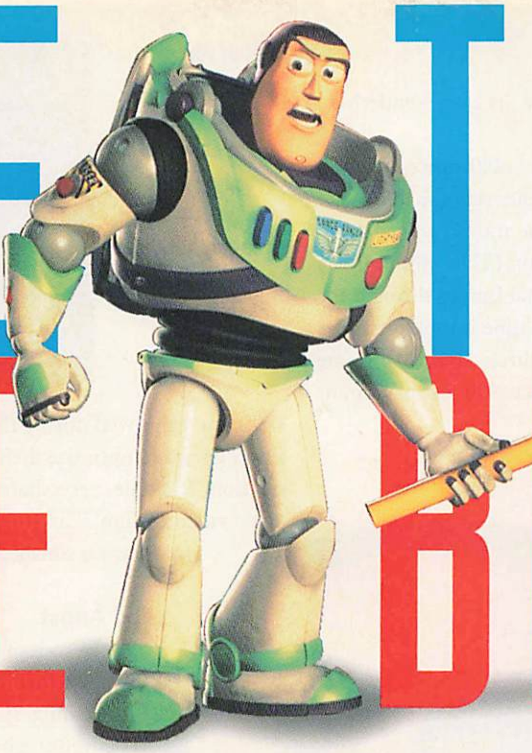
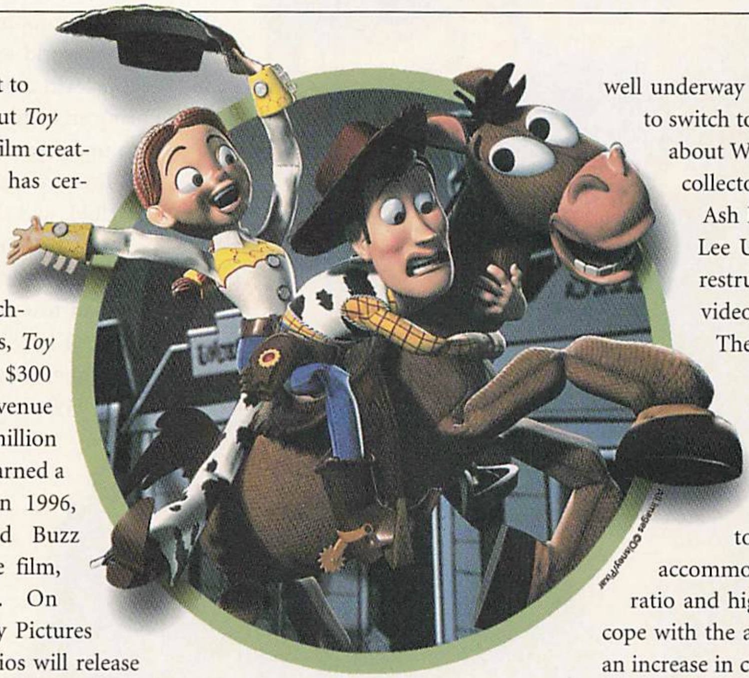


## BY APPLYING TECHNICAL INNOVATIONS FROM PREVIOUS FILMS, PIXAR ADDS DEPTH AND DETAIL TO TOY STORY 2

BY BARBARA ROBERTSON



**Bullseye and Jesse show Woody what it's like to be a cowboy in *Toy Story 2.* Behind them is a scene from the black-and-white TV show *Woody's Round-Up,* created, as are the characters, with 3D graphics.**

All images ©Disney/Pixar

It may not have made it to infinity and beyond, but *Toy Story,* the first feature film created with 3D graphics, has certainly made it into the filmmaking and computer graphics history books. A critical, technical, and financial success, *Toy Story* generated more than $300 million in box office revenue worldwide and over $100 million in rental fees. The movie earned a special Academy Award in 1996, and turned Woody and Buzz Lightyear, the stars of the film, into household names. On November 24, Walt Disney Pictures and Pixar Animation Studios will release *Toy Story 2,* a sequel to their 1995 film. Directed once again by Pixar's John Lasseter and created at Pixar, the sequel brings back Woody, Buzz Lightyear, and the rest of the toys from Andy's room as well as the entire voice cast including Tom Hanks as Woody and Tim Allen as Buzz.

Sequels to Disney animations are usually created as direct-to-video releases, and that was the original intention for *Toy Story 2.* In fact, the video production was well underway when the studios decided to switch to film. "The basic storyline about Woody being stolen by a toy collector stayed the same," says Ash Brannon, co-director with Lee Unkrich, "but it had to be restructured from an hour-long video into an 80-minute film." The change gave the storytellers more elbow room for plot twists and turns, he says, but it also meant more work for the film crew, who had to reframe everything to accommodate film's wider aspect ratio and higher resolution, as well as cope with the additional 20 minutes and an increase in complexity.

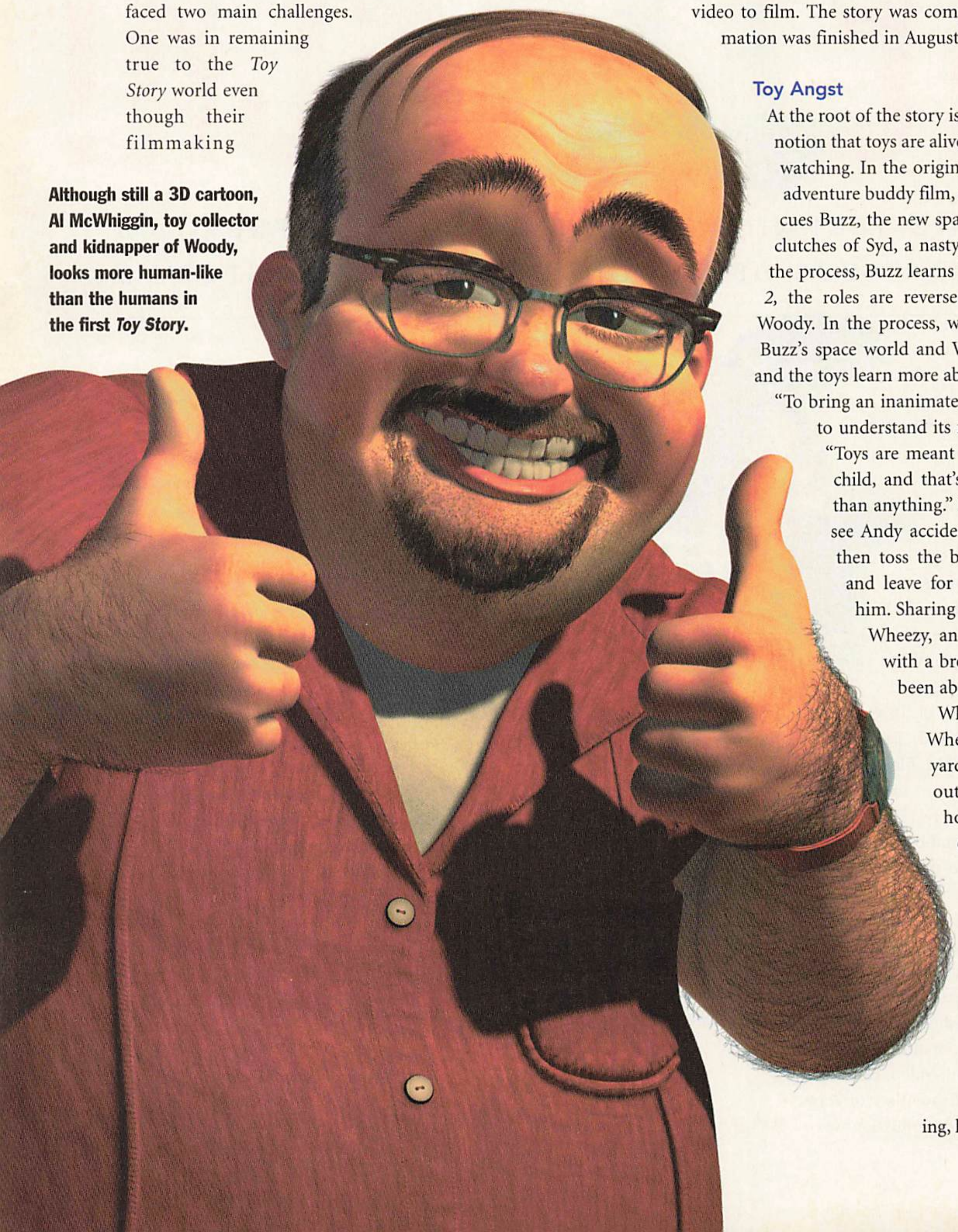
"*Toy Story 2* is twice as complex as *A Bug's Life,* which was 10 times more complex than *Toy Story,*" says Ed Catmull, Pixar's founder and chief technology officer, "and the production time was shorter." Pixar uses Alias|Wavefront's (Toronto) Alias Studio for modeling, Interactive Effects' (Irvine, CA) Amazon Paint for painting, and a host of custom software for such tasks as modeling, animation, and compositing—all running on SGI machines. For rendering, the studio used its own RenderMan software running on Sun machines.

Pixar's renderfarm has now grown to 1400 processors and even so, *Toy Story 2* pushed the studio's rendering capabilities to the limit. There are 122,699 frames in the movie, according to Thomas Jordan, render technical director (TD), who, with a team of 10 "render wranglers," herded final frames through the render pipeline. According to Jordan, the time it took to render each frame ranged from 10 minutes to three days, with frame sizes as large as 4GB. The fastest output was 930 feet of film, or 14,880 frames, in one week.

**When you're only a few inches tall, you need to be clever to cross a busy street. It's touch and go, but Andy's toys all make it to Al's Toy Barn.**

All images © Disney/Pixar

In addition to the problems of complexity, the artists and technical staff at Pixar faced two main challenges. One was in remaining true to the *Toy Story* world even though their filmmaking skills had improved during the past four years. The second was finding ways to optimize their work to meet an accelerated production schedule necessitated by the switch from direct-to-video to film. The story was completed this spring; animation was finished in August.



**Although still a 3D cartoon, Al McWhiggin, toy collector and kidnapper of Woody, looks more human-like than the humans in the first *Toy Story*.**

## Toy Angst

At the root of the story is Lasseter's now familiar notion that toys are alive—when humans aren't watching. In the original *Toy Story,* an action-adventure buddy film, cowboy toy Woody rescues Buzz, the new space ranger toy, from the clutches of Syd, a nasty, toy-destroying kid. In the process, Buzz learns he is a toy. In *Toy Story 2,* the roles are reversed: Buzz has to rescue Woody. In the process, we all learn more about Buzz's space world and Woody's western world, and the toys learn more about themselves.

"To bring an inanimate object to life, you have to understand its function," Lasseter says. "Toys are meant to be played with by a child, and that's what toys want more than anything." Early in *Toy Story 2,* we see Andy accidentally rip Woody's arm then toss the broken toy on the shelf and leave for cowboy camp without him. Sharing the shelf with Woody is Wheezy, an asthmatic toy penguin with a broken squeaker, who has been abandoned to gather dust. When Andy's mom drops Wheezy into the 25-cent yard-sale box and takes him outside, we understand how very wrong things can go for a toy. But in a daring maneuver, Woody rides bareback to the rescue on Buster, the family's dachshund, and saves Wheezy. Unfortunately, Woody falls off outside and, because the humans are arriving, has to freeze in place.

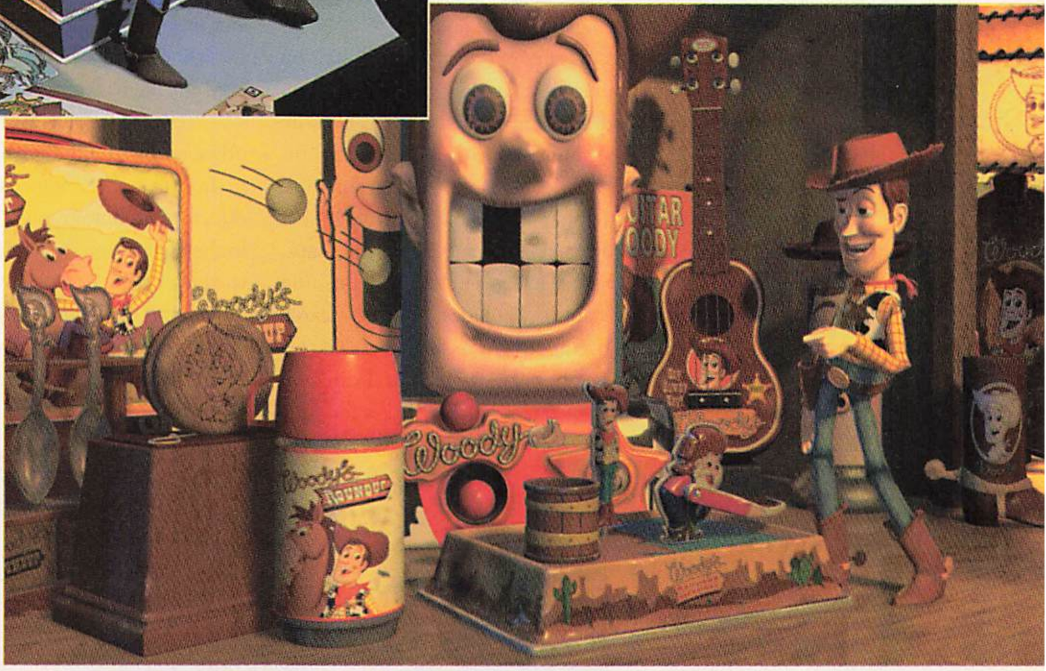
Andy's toys watch in horror as Al of Al's Toy Barn, a broker of toy collections, steals Woody, and this sets the stage for Buzz's rescue. Al has taken Woody to his apartment and there, Woody is amazed to discover that he has a past: Woody was the star of a 1950s TV cowboy show. Al has collected toy versions of the other stars from *Woody's Round-Up*—Jesse the cowgirl, Pete the Prospector, and Bullseye, Woody's horse—along with tons of memorabilia like lunch boxes, comic books, record players, hats, belts, and so forth. With Woody added to the collection, it's complete, and Al takes everything out of storage.

That sets up the conflict: Will the nicely repaired Woody stay with his new friends so the collection can go to a museum where he'll be taken care of forever? Or, if Buzz and Andy's toys arrive in time, will Woody go back with them and risk being abandoned by Andy? "This is an animator's dream," says Glenn McQueen, supervising animator, who led the team of 66 animators. "Every sequence has gold."

**To create the light shining on Woody's face and in the room, Pixar emulated the particular color of light emitted from a black-and-white TV set in the '50s.**

For the animators, many of whom worked on the first film, one of the most difficult scenes in *Toy Story 2* was the first one, according to McQueen. "Because we see Woody and Buzz every day, the temptation is to break the mold. But the first time the audience sees the characters, we have to be sure that we've caught the essence of the characters and that there is nothing tricky in the performances," he says.

Similarly, the familiar characters had to look like they did four years ago—as did the *Toy Story* world. Yet, during those four years, Pixar had released the short film "Geri's Game," starring a character who was unarguably a technically and artistically better human than those in *Toy Story*, and the studio had created a second feature film, *A Bug's Life*, in which far more complex lighting and shading models were used to create a visually richer environment than in *Toy Story*. The trick was to use the improved technology selectively. *Toy Story 2's* new human, Al, for example, is more complex than Mom and Andy; however, Mom and Andy have been improved, too. The standard line at Pixar is that Mom's got a new wardrobe, a new "do," and has been working out—but she still looks like Mom. "We didn't set out to produce the perfect realistic human," says Lasseter. "The humans are still cartoons." But even so, they're more realistic than the humans in *Toy Story*—particularly, Al.



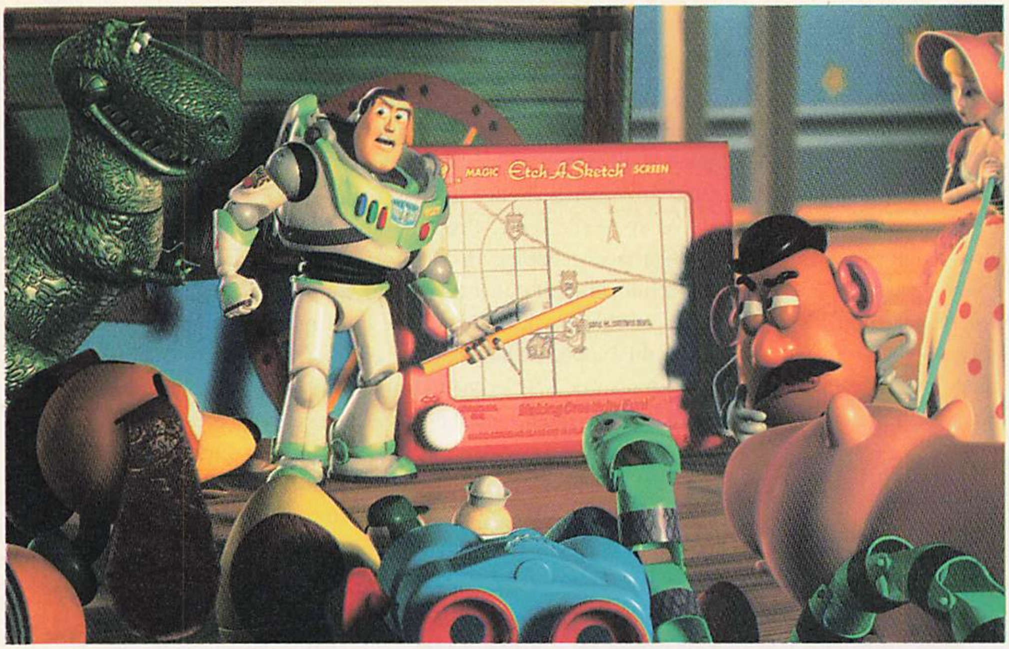
**If you look closely, you can see yellowed printed material, little scratches, and paint worn off metal surfaces that tell you this collection is old but well-maintained.**

### The Human Element

"Al's hideous in this great way, and he's a very complex model," says Eben Ostby, modeling supervisor. "If I had to make a rough guess, I'd say that all the source files that make him up come to 200MB. Woody is about a tenth of that."

As in "Geri's Game," Pixar's technical directors used subdivision-surface technology to help create the skin for Al and the other humans. But rather than try to simulate the physical properties of skin, as they did for the humans in the original *Toy Story*, they applied what they learned from *A Bug's Life* to create surface texture. "We learned what shaders and painters can do well, so rather than model the skin physically, we created tools for the painters," says Brad West, shading supervisor. More specifically, the TDs developed a giant RenderMan shader that could create such skin characteristics as pores, blotchiness, veins, shininess, sweat, and so forth, and even whiskers that the shader could grow procedurally. Those individual characteristics became the painters' tools when the TDs added them to the Amazon Paint interface.

The painters started with a basic rendering of the model, then painted layers on top to fine tune the rendering. Al has the most detail, but because they didn't want Al to look too different from the other humans, they also added detail to Mom and Andy. "We just don't have the camera get as close to them," West says. "My favorite part of Al is his whiskers," he adds. "He has a five o'clock shadow, his skin is blotchy, and in one area he has a small scar where there are no whiskers. He even has white-

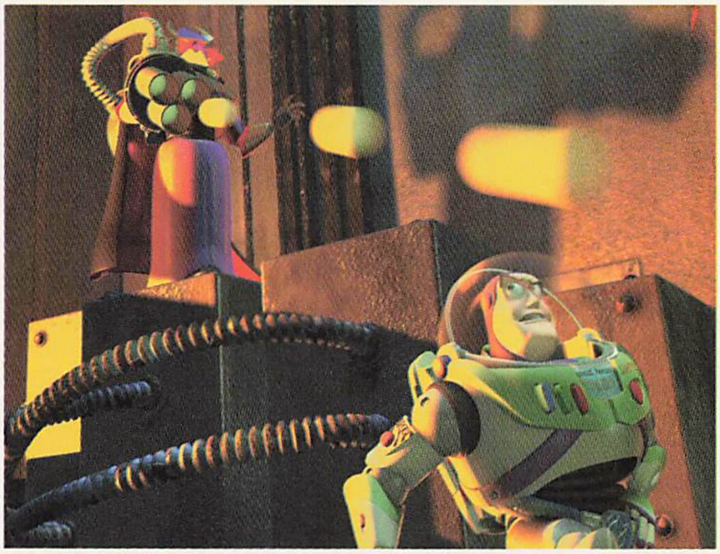


**Planning Woody's rescue while Rex, Slinky Dog, Mr. Potato Head, Hamm, Bo Peep, and other toys from Andy's room look on is Buzz Lightyear.**

heads." To create the lines under Al's eyes and around his mouth, the painters used displacement shaders. To create the hair on his arms, the TDs used geometry.

Pixar used two different techniques to create hair. For hair on rigid surfaces such as a human's skull, Guido Quaroni, a TD on the human modeling and shading team, created an Alias plug-in. The plug-in gave the TDs guide hairs made of geometric primitives that they could use to describe the look and movement of thousands of hairs when rendered. For hair on deformable surfaces like Al's arms and the dog, the painters used texture maps.

To create clothes, the TDs chose to sculpt cloth into position rather than use a dynamic cloth simulation. "The research department was still working on the simulator for "Geri's Game" when we started," says Oren Jacob, associate technical director. "Geri is a skinny old man wearing a baggy jacket. Al is a fat dude with clothes stretched taut, and he was going to be in many more shots that Geri." So, they decided to model the creases and folds for certain poses, then use shape interpolation between the changes in position. "All the animators had to do was animate the model and the clothes would follow," Jacob says.



**To keep a crisp leading edge on the glowing energy balls being fired at Buzz by his archenemy, the evil Emperor Zurg, the effects team blurred the objects one-half frame backward in time.**

"We have tons of geometry in this film," says Galyn Susman, supervising technical director. "In *A Bug's Life*, the complexity was in the surfaces. In *Toy Story 2*, the complexity is in the geometry." She notes that two of the most geometrically complex scenes take place in a downtown area and in an airport.

"Downtown is extra heavy," agrees Jordan. "Every block had 10 trees or more, every tree has thousands of leaves, every car has one or two people, and every person has thousands of hairs." Then there are buildings, grates, stoplights, and parking meters. The buildings have facets and windows with dirt on them. "None of it is fake," says Susman of the downtown scene. "It's all geometry. Sure we could have painted it, but we've been keeping the camera very fluid. Once you move the camera, even a little, the trained eye knows something is wrong."

All this geometry helps make scenes visually complex, but it's the way in which the models interact with light that makes them visually rich. "We used a lot of techniques from *A Bug's Life* that help the lighting create visually richer scenes," says Ostby, "We rounded edges to create a place that catches light and we avoided making things that are too flat—even for the background props."

"We've rewritten the way surfaces and lights talk to each other, and we used the new tools and processes from *A Bug's Life* to improve this movie artistically," explains Sharon Calahan, director of photography. "We think cinematically, yet we're also in the illustration world. We create physics and make a believable world, but it's not real. We want painterly influences, but we don't want to flatten things out. We want spaces that look deep. We're evolving our own studio look, and that's the fun part. I think that overall, this film is softer and has more depth than *Toy Story*. But I still hope it feels like the original."

To create *Toy Story*, the studio used 366 objects. In *Toy Story 2*, there are approximately 1200 models that range in size from a pencil to an airport—plus variations, according to Susman. For the human "extras," the modelers mixed and matched pieces from about a half dozen models. "We'd put different faces on the same body and vice versa," says Ostby. To help the animators create performances for the extras, the R&D department developed new articulation controls for

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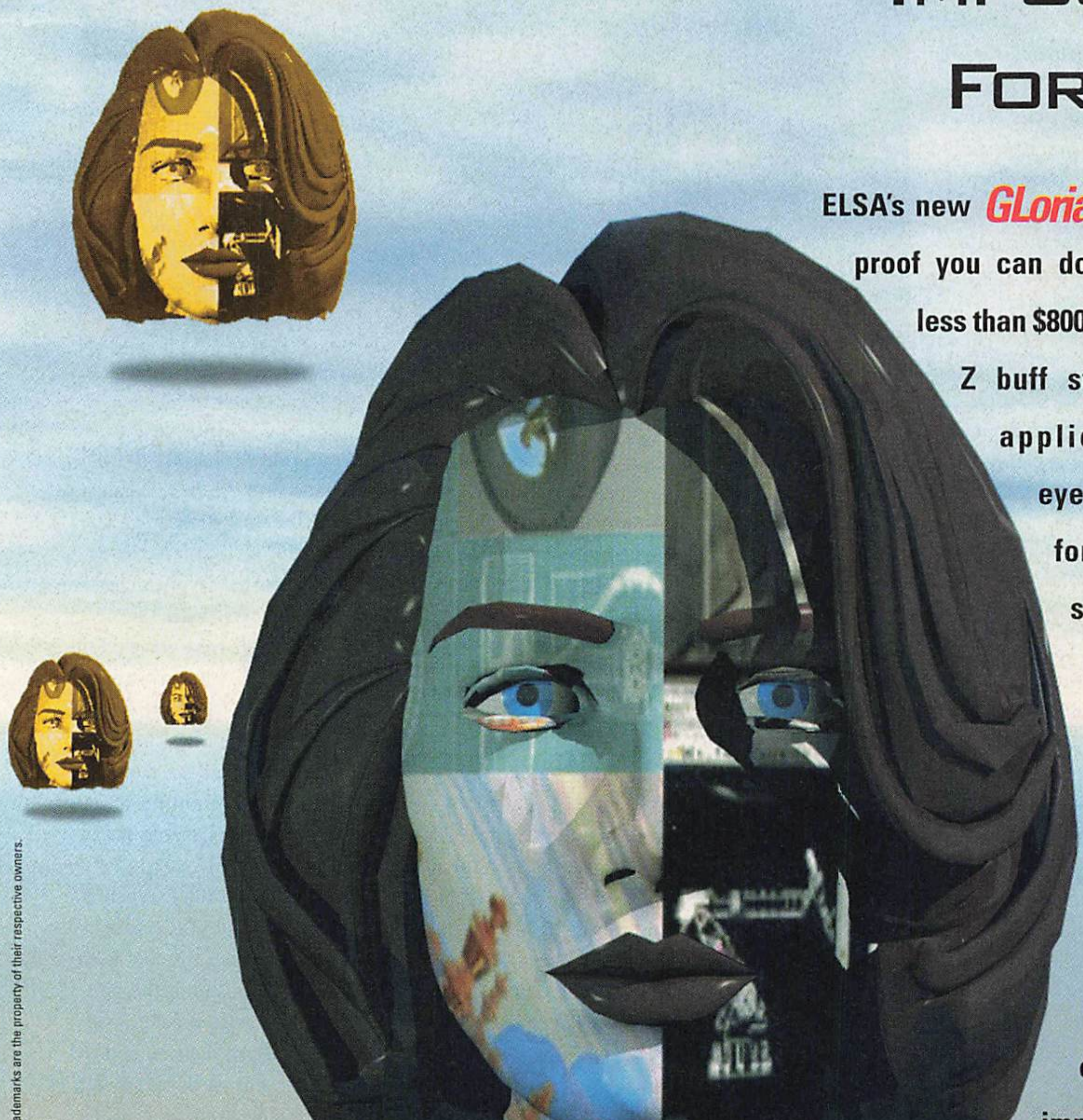

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the models. Called "Geppetto," the software, which was written by senior scientist Tony DeRose and graphic software engineer Dirk VanGelder, evolved from Pixar's proprietary "PET" (Patch Editing Tool) technology.

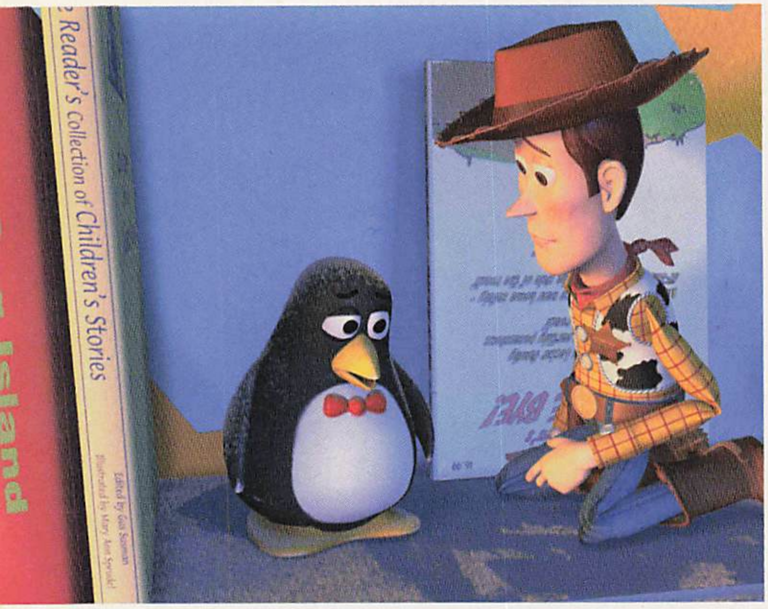
"Geppetto is a way of grouping points and tying an articulated variable to them," explains Susman. "It gives us a way to build armatures and transfer them from character to character and to define what happens procedurally." With Geppetto, a modeler could import an entire armature to another human, and it would need only fine-tuning to accommodate different sizes.

**Lighting conditions in *Toy Story 2* range from bright daylight to nighttime scenes such as this one in which Buzz and the toys race to Woody's rescue in a Pizza Planet truck.**

## Special Effects

This attention to detail is evident in the effects, as well. For example, Pixar created clips from Woody's TV show using 3D computer graphics. That animation was rendered in color, converted to NTSC black-and-white video, then run through a compositor to add jitter, negative scratches, hair, coffee stains, scan lines, video bloom, and static—everything that might have happened to a Kinescope created for television in the '50s. The result was mapped onto a CG model of a Philco TV set, then warped to fit the screen. "We went through all the stages as if the show had been created with the old process," says Jacob.

Even the dust on Wheezy's shelf is created carefully. "We could have used particle effects to create dust, but we didn't think it would be convincing," says Jacob. "Instead, we decided to stick millions of pieces of stuff in the shot"—2.4 million pieces of stuff, to be precise, including tiny "hairs," two-to-three pixel-wide flecks, and little spheres. "The shelf is covered by an 1/8-in.-thick crust of dust that's spongy," Jacob says. "It has an internal structure." So when Woody puts his hand into the dust, the dust compresses, and when he lifts his hand, the dust sticks to it. The effects team also created dust bunnies using a volumetric structure. "We put them in the model catalog so the layout department could place them where they wanted," says Jacob.



**Covered with dust, Wheezy tells Woody that he's been forgotten. The dust is geometry, not a particle effect.**

Some of Jacob's favorite effects shots, though, were created for the space sequences—explosions, shockwaves, and crowds of robots. "In one shot, Buzz is surrounded by 280,000 individually articulated robots all shooting at him at the same time," he says.

"One of the successes of *Toy Story* is that toys are great subject matter for 3D animation," says Lasseter. "You can put in details you couldn't do in hand-drawn animation: stickers, seams, rivets, screws, clear helmets, plaid shirts, and denim jeans."

To help deal with that detail, Pixar developed many schemes for optimizing the production, including, for example, automatically generating details depending on how close a model is to the camera. "A human might have 200,000 hairs, but if the camera is very close or very far away, you only need to use 500," says Susman. To help a tired crew at the end of production, and to have more control of the final product, Pixar is working on digital color timing. "When we did the first *Toy Story,* we had the idea that once we were in production, we wouldn't change software," Catmull says. "It turns out that's incorrect. We have to change. So we worked out methods for allowing that change."

"At Pixar, technology is developed in service to story," says Lasseter. "I think people will be surprised at this story. The humor and adventure from the first *Toy Story* is there, but the level of emotion that especially Woody and Jesse go through is deeper. The things that prevent toys from being loved are being broken, lost, and stolen, but the most difficult is being outgrown. We get to see that from a toy's point of view."

It's true that toys are usually outgrown, and technology, for that matter, is outgrown, too. But stories can live forever.

*Barbara Robertson is West Coast Senior Editor for* Computer Graphics World.

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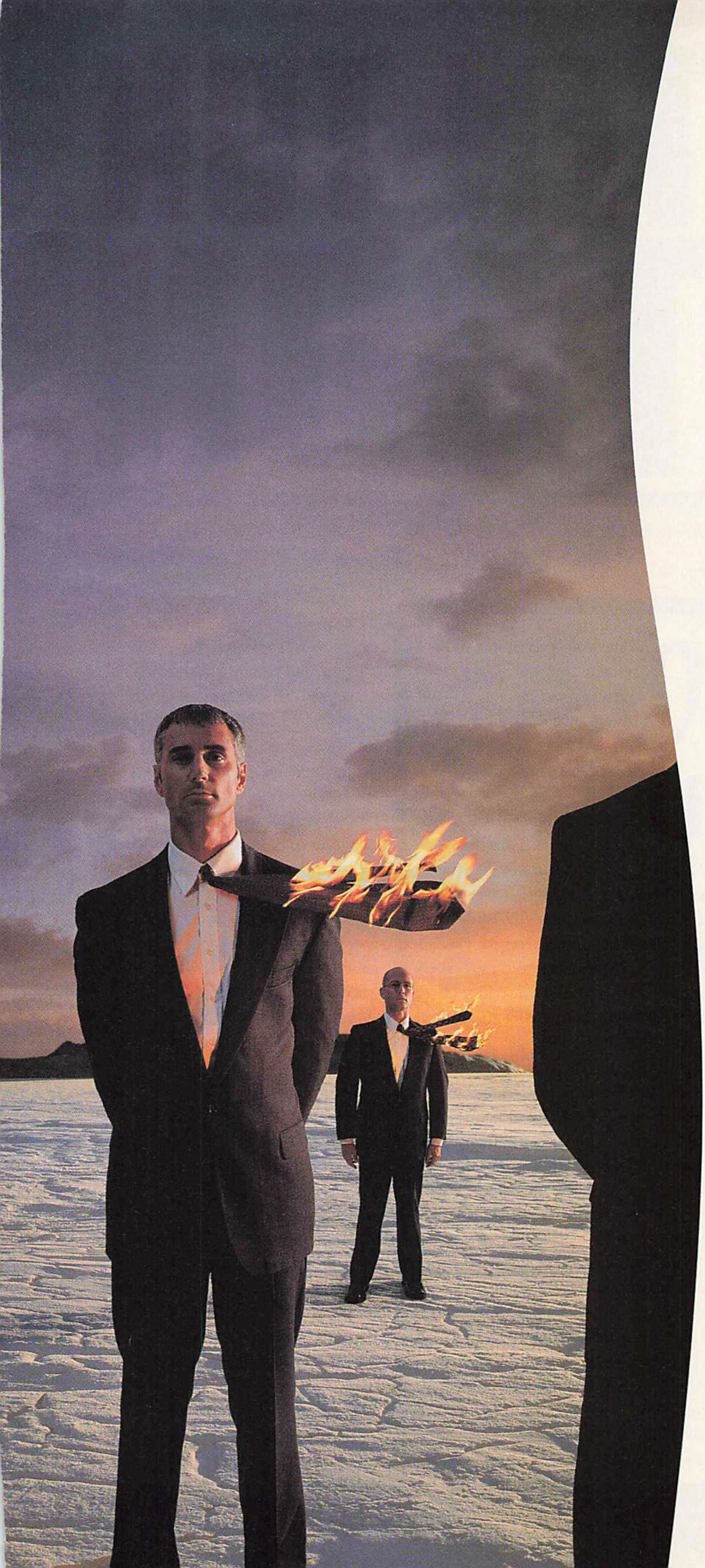

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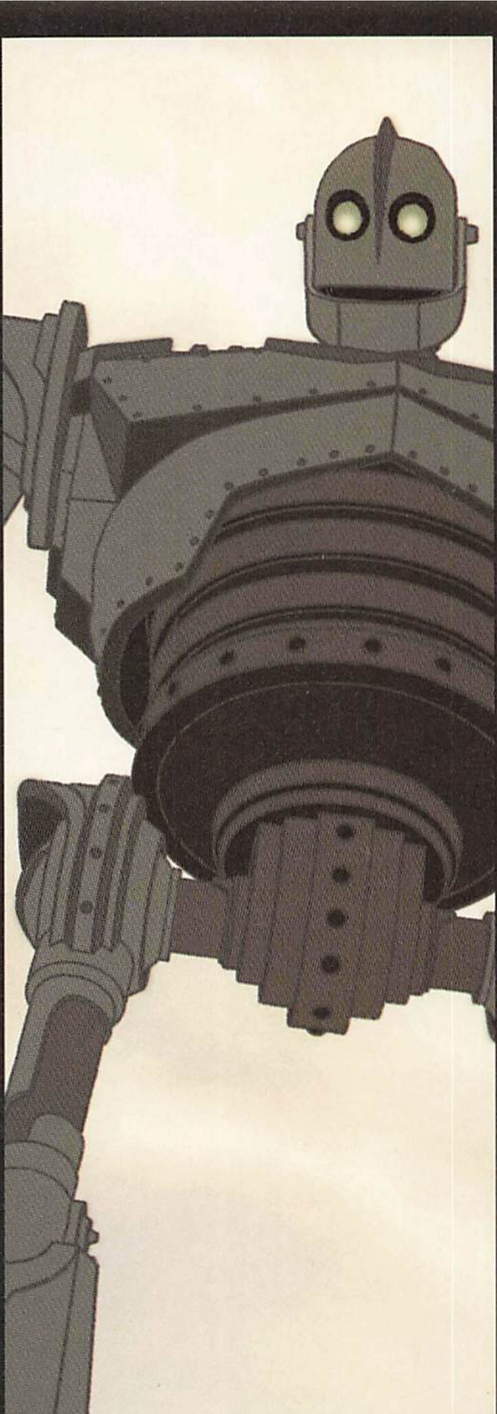


**Made with 7000 parts, the Iron Giant is a 3D model created in Maya, rendered as a cartoon in Renderman, then imported into Cambridge Animation Systems' Animo.**

# TEN-TON TOON

## WARNER BROS. DEVISED NEW TOOLS TO FIT A 3D ROBOT INTO THE 2D ANIMATED FILM, THE IRON GIANT

BY BARBARA ROBERTSON

Sometimes everything about a movie can be right—story, direction, acting, and art—yet the movie becomes a box-office disappointment. It happened this summer to *The Iron Giant,* an animated feature from Warner Bros., based loosely on the 1968 story *Iron Man* by British poet laureate Ted Hughes and directed by Brad Bird, who has also directed the animated TV show, *The Simpsons.* The movie received glowing reviews on the Internet from moviegoers and in the press from movie critics. Harry Knowles, influential host of the Ain't It Cool News movie Web site, raves, ". . . purely and surely, one of the greatest films, animated or live-action, I have taken into my heart." This month, Warner Bros. plans to release video and DVD versions, and reportedly will launch them with a new marketing campaign.

*The Iron Giant* takes place in the small town of Rockwell, Maine. It's 1958. Russia has launched Sputnik and plunged the US deep into Cold War paranoia. The story centers on Hogarth Hughes, a headstrong nine-year-old voiced by Eli Marienthal; his single mom Annie Hughes (Jennifer Aniston), a waitress in a diner; the Iron Giant (Vin Diesel), a 50-foot robot who drops from the sky; Dean McCoppin (Harry Connick, Jr.), a beatnik junk dealer and sculptor; and Kent Mansley (Christopher McDonald) an over-zealous government agent. One night when Hogarth is home alone watching TV, the transmission suddenly stops. He quickly sees why: The antenna is missing. Determined to find it, he follows a clear path through the woods that leads to the power station. There he spots a 50-foot-tall "metal man" munching the antenna, power towers, and other metal parts. When Hogarth switches the power off to save the robot from electrocution, he earns the Iron Giant's loyalty. Meanwhile, Mansley, who has heard rumors of this alien monster, becomes determined to find and destroy it.

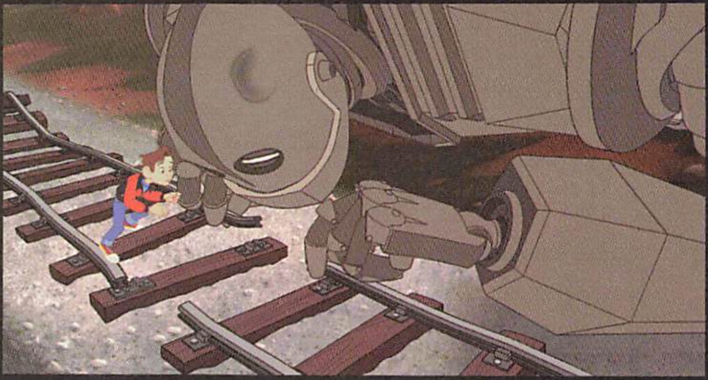
### A Giant Task

All the characters in the film are 2D animations created in Cambridge Animation Systems' (Cambridge, UK) Animo, with the notable exception of the Iron Giant himself, the first title character in a 2D animated film to be created with 3D computer graphics. The Giant was modeled with Alias|Wavefront's (Toronto) Maya, rendered with Pixar's (Pt. Richmond, CA) Renderman, and imported into Animo. "We chose to do the Giant in 3D because he did not belong in the Rockwell, Maine, cartoon world," explains Tad Gielow, CGI department head at Warner Bros. "By using CGI [3D computer graphics imagery], we could give him a different feel and a more mechanical look than the 2D characters."

To build and animate the Giant and create software that would render him as a cartoon in Animo-friendly formats, Gielow organized a team of 34 technical developers and directors. The team was so successful they found themselves creating 3D props—51 in all, according to Gielow. "The pipeline was very efficient," he says. "We did over 1000 feet of prop work that was not in the original plan." Among the props were machines such as jeeps, cars, trucks, tanks, bicycles, motorcycles, and jets, as well as things the Giant interacted with, such as junk in the junkyard, parts from the power station, train tracks and railroad ties, and a rock. Most difficult, though, was the Giant himself.

The Giant required more than one model: In addition to creating a "normal" Giant, digital sculptor Hiroki Itokazu used Maya to create a broken Giant, a battle Giant, and the Giant as a sculpture. The normal Giant has 7000 parts; the Battle Giant has 10,000 parts.

In order to place the Giant into the animation, every visible surface of those parts had to be rendered as a "toon," that is, inked, painted, and converted into Animo files. To do that, they needed to convert Maya files into Renderman RIB files and the 2D rendered output into Animo format. With no commercial software available in 1997 to do this, they began "rolling their own." Andy King worked on the Maya conversion; Brian Gardner created an entire image-processing pipeline, now named "Gartoons," to render the models and create Animo Layer Files.


**In this scene, Hogarth is a hand-drawn element. The Iron Giant and the railroad rails and tracks are 3D models.**

"Brad Bird was keen to have the CG look like hand-drawn animations from the '40s," says Gardner, "but it struck me that although CG [3D computer graphics] has worked for backgrounds in film, it has not worked very well for characters," he says. Thus, when Gardner received the mandate to create a system for *The Iron Giant,* he began interviewing people in the color-modeling and markup departments to learn what they needed to make a CG character fit into hand-drawn animation. He discovered that they wanted to receive Animo Level Files that were inked and painted but not irreversibly; that is, they wanted the option to change the colors of the rendered images.

## Wobble and Glomp

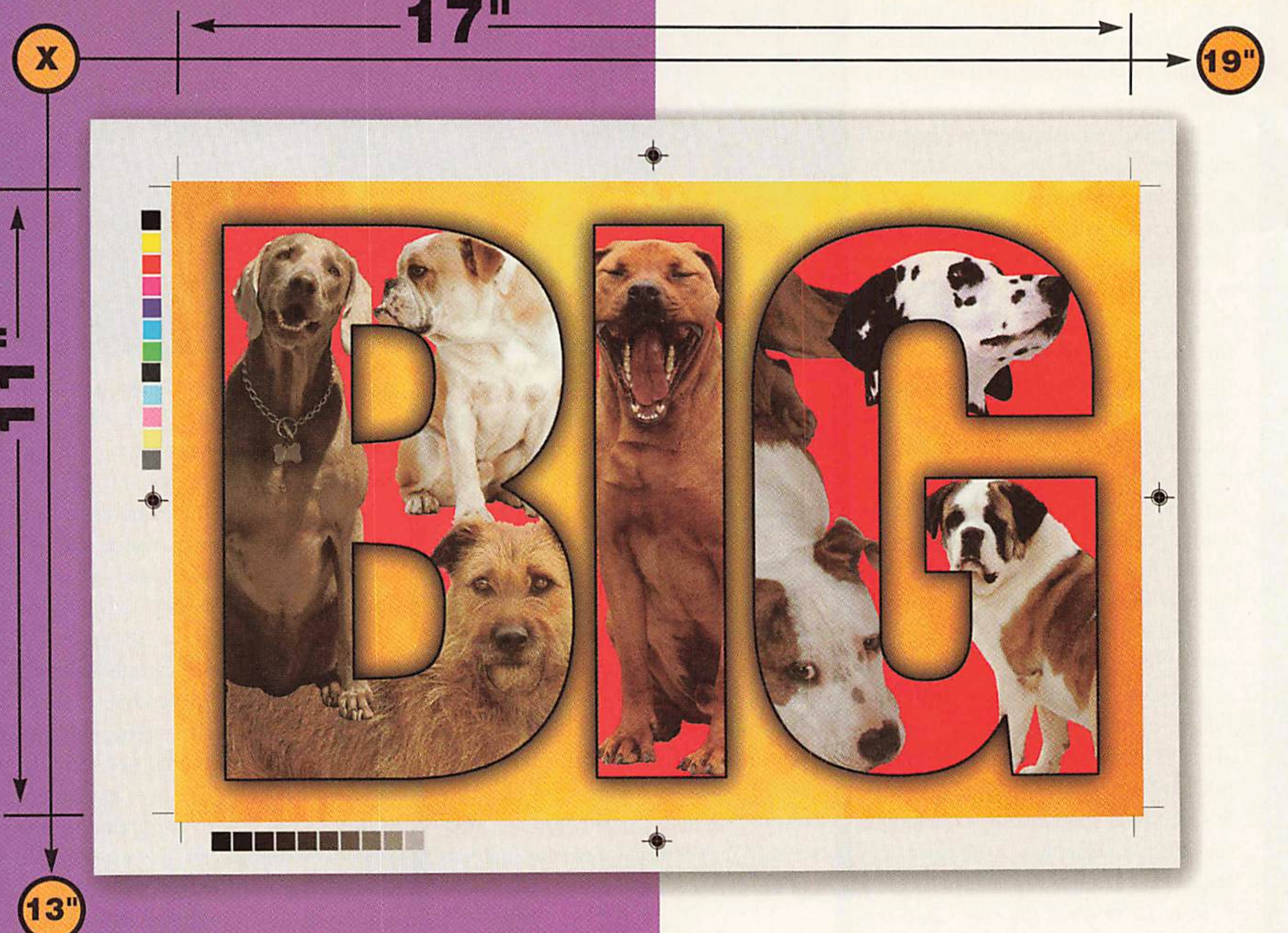
The first problem to solve was producing inked lines that correctly defined the Giant's parts and looked hand-drawn. Using Renderman, Gardner created a Gartoons shader that drew textured lines of varying thickness, a technique he named "line glomping." In addition, he added line wobble to Gartoons to create temporal antialiasing from frame to frame. This allows rendering on "twos" (every other frame) so that the CG animation will match similarly drawn 2D animations without strobing. And, as requested, Gartoons produces several ink, paint, and matte layers as Animo Level Files, each controlling such things as line color and matting for tone, highlights, and effects.

To avoid rendering separate passes for each layer, Gardner created plug-ins for Renderman's device drivers as well as for the shaders. Device drivers care about entire images in 2D space, he explains, while shaders care about single pixels in 3D space. By encoding 17 channels of color and surface attributes into three color channels that are fed to a device driver and later expanded, Gartoons can render everything in one pass. The result can be a particular Animo layer needed by a department or a preview of a composite image. Gartoons can put each layer into a separate buffer, then display a composite image, which allows a kind of interactive rendering as colors are changed. "Once the buffer data is recalculated, the screen is repainted," Gardner says.

In addition to Gartoons, another innovative tool used for the film was a 3D/2D camera integrator that Gielow created as a plug-in for Maya. "This allows animators to match the Giant to the layout," he says. The blend seems to have worked well enough to draw people into the story and capture the hearts of children and adults alike. Adults like the witty satire and the message that we can choose not to be weapons. And one six-year-old posted this review on the Internet Movie Database site (http://imdb.com): "I liked the Iron Giant. They tried to hurt him because they didn't understand him. That's not nice. You have to try to get to know someone . . .This was a good story without so many songs, and it made me interested for a long time."

**To animate the Iron Giant, Warner Bros. used Maya. To render him as a 'toon, the studio created custom plug-ins for Renderman.**

*Barbara Robertson is Senior Editor, West Coast, for* Computer Graphics World.



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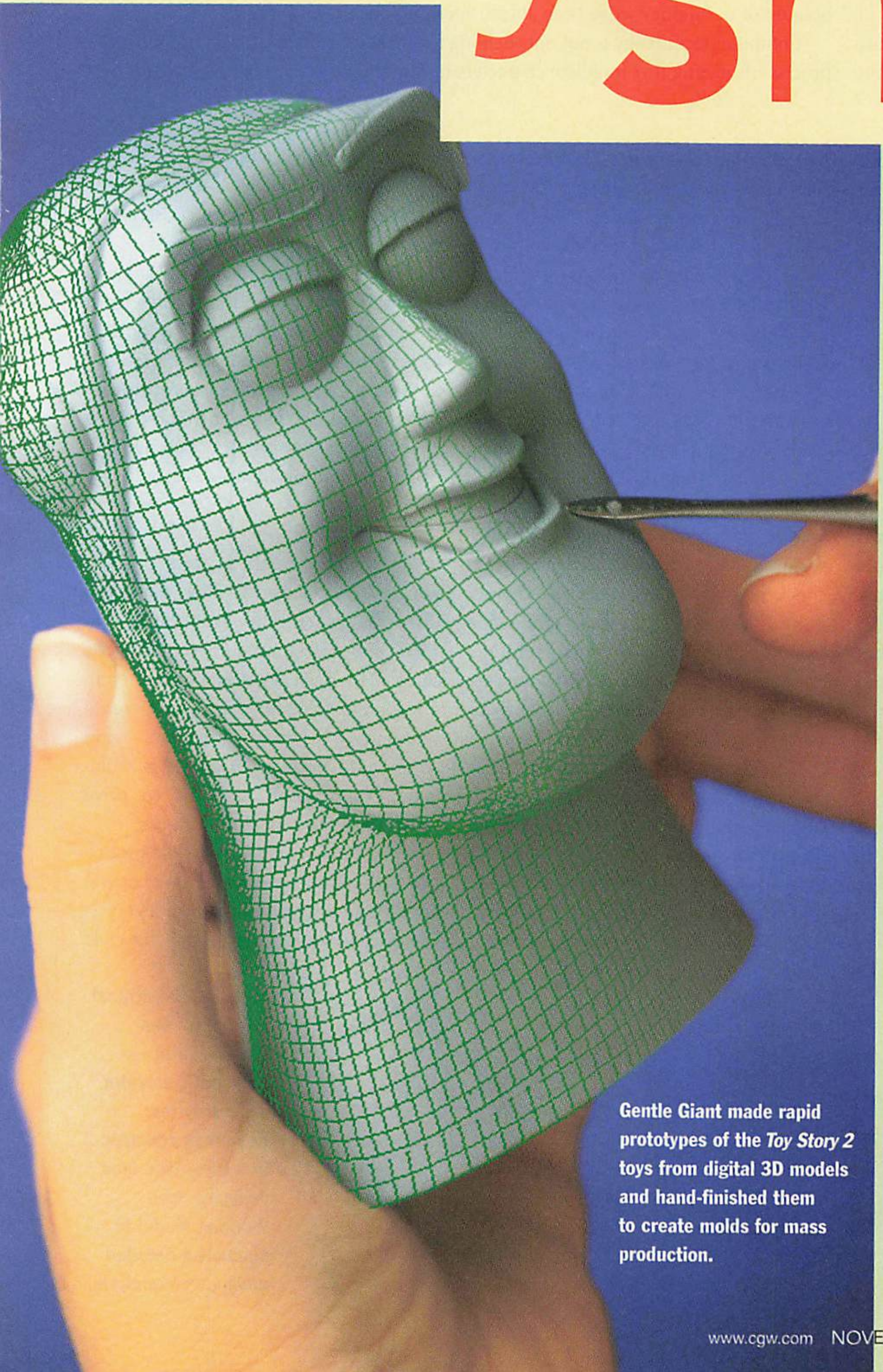
# digital toy shop

**To model Buzz, Woody, and other *Toy Story 2* toys, Gentle Giant imported animation data into Alias|Wavefront's Maya to pose the characters as desired.**



**Gentle Giant made rapid prototypes of the *Toy Story 2* toys from digital 3D models and hand-finished them to create molds for mass production.**

## TO TRANSFORM ACTORS INTO ACTION FIGURES, DESIGNERS TURN TO COMPUTER TECHNOLOGY

### BY CAREN D. POTTER

When my brothers were growing up they had great fun playing with their "army men." These little olive-green plastic figures, which came in about a half-dozen different shapes, all had the same squinty-eyed grimace. How different it would be if my brothers were growing up today. Assuming they were allowed to have army men at all, they'd probably be playing with action figures of characters from the movie *Toy Soldiers.* Or perhaps more likely, they'd have reproductions of Qui-Gon Jinn, Obi-Wan Kenobi, and Darth Maul from *Star Wars Episode One: The Phantom Menace.* In any case, rather than playing with generic, one-face-fits-all characters, they would have toy replicas that looked just like their on-screen counterparts.

Creating toy facsimiles of movie characters is big business in the toy industry today. The figures can be based on live humans, such as Kay and Jay of *Men in Black.* (In fact, there are *Men in Black* action figures with faces that are almost identical to those of Tommy Lee Jones and Will Smith.) Or the toys can be based on animated characters such as Buzz and Woody from *Toy Story 2* (see "The Toys Are Back," pg. 27).

There are two big challenges to turning movie characters into toys. First, no matter what the toy is, from a huge stuffed object to a bauble on a key ring, it must closely resemble what people have seen on the big screen. Even an item as small as a Buzz Lightyear pencil topper can't just have a space helmet and the general shape of a spaceman. It must look like Buzz.

"You can't blame the licensors" [the studios that own rights to the characters], says Robert Curet, vice president for creative development at Playworks, a toy-prototyping sculpture house in Westlake Village, California. "They worked so hard to design those characters, they want to make sure that what is sold is the same as what they created."

The other challenge is that movie toys need to be available when the movie opens or very soon thereafter. This means that toy makers often have less time to make the products than the movie company has had to make the movie. Meeting that deadline is becoming increasingly difficult. "We used to get the go-ahead a year before a movie came out," says Karl Meyer, president of Gentle Giant Studios, a licensed-product builder in Burbank, California. "But, it's a faster pace now. People are able to make movies more quickly, and, as result, our advance time is getting shorter. Fortunately, because of technology we've been able to speed up our process as well."

Computer technology is not only helping toy makers save time. It also simplifies the process of making toys look like characters in movies. Consider how a movie toy was

## toying with CAD

Not every toy maker has to create products that perfectly match someone else's vision. Many of them are permitted to let their imaginations run wild, at least in terms of what the toy looks like. "It's a tough job, but someone's got to do it," say the inventors, as they sit on the floor and put their prototypes through the paces.

But there are constraints—such as issues of safety, manufacturability, cost, suitability for the target age group—that toy designers must consider. In fact, on closer inspection, the business of developing toys begins to seem less like play and more like the serious work of designing any product. The task is to come up with a high-quality item that addresses a certain market niche, and to do so as quickly as possible at the lowest cost. As you might imagine, nearly all the large toy manufacturers use CAD to help them do this.

Look through any child's room, and you'll see toys that were designed with Pro/Engineer (Hasbro's Nerf Wildfire; Mattell's Barbie Airplane, Barbie Digital Camera, and Barbie Jewelry Maker); Unigraphics (Legos); AutoCAD (Aerobie Flying Disk, Aerobie Football); Solid Edge (Playmaxx ProYo yo-yos), and SolidWorks (the Rokenbok system). This list could be much, much longer. But while some toy makers will admit privately to using CAD, they don't want to talk about it for fear of giving away trade secrets in the highly competitive toy manufacturing business.

Toy designers use CAD for the same reasons other manufacturers do. They assemble the product on-screen to check fit, they make rapid prototypes from CAD data, they use CAD files for programs that drive manufacturing machines, and they import CAD models into structural and mechanism-analysis programs to simulate performance.

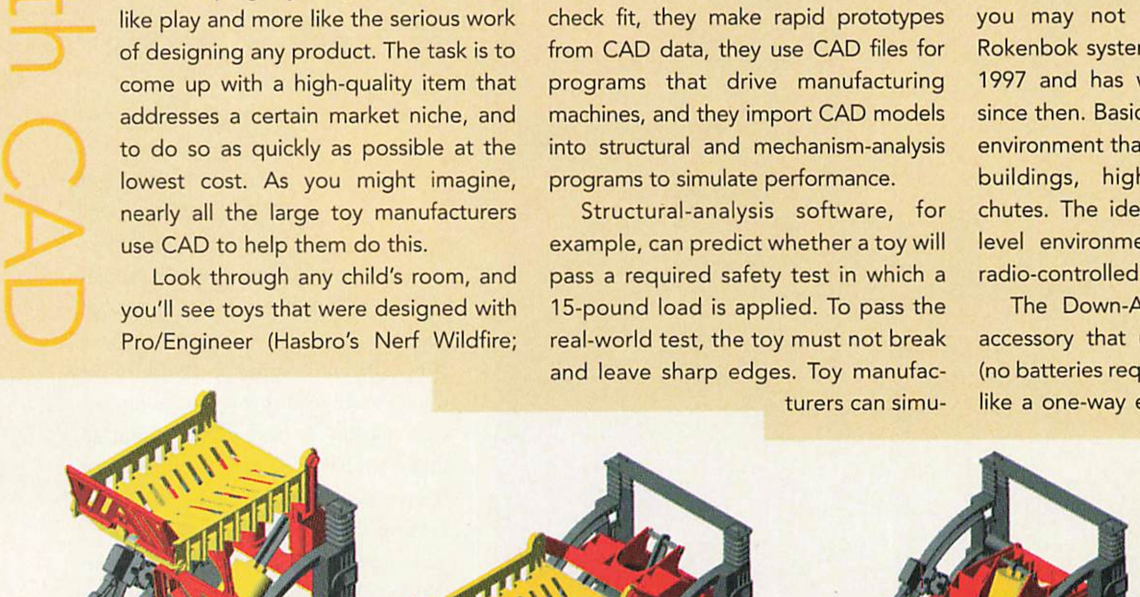
Structural-analysis software, for example, can predict whether a toy will pass a required safety test in which a 15-pound load is applied. To pass the real-world test, the toy must not break and leave sharp edges. Toy manufacturers can simulate the application of the 15-pound load to the digital model, then reinforce the design if the analysis results show overly high levels of stress.

Toy makers use mechanism analysis to simulate the action of toys with moving parts. Sometimes they do this to address safety concerns and sometimes they do it to make sure they've got the motion they want. Sometimes both issues are important, as they were on the Rokenbok Down-A-Vator.

### Simple Toy, Complex Mechanism

If you haven't bought toys for a while, you may not be familiar with the Rokenbok system. It was introduced in 1997 and has won numerous awards since then. Basically, it is a construction environment that children use to create buildings, highways, bridges, and chutes. The idea is to create a multilevel environment in which to drive radio-controlled Rokenbok trucks.

The Down-A-Vator is a Rokenbok accessory that uses pneumatic power (no batteries required) to lower a vehicle like a one-way elevator. After the child



**To refine the critical linkage for the Down-A-Vator—a pneumatic elevator accessory for Rokenbok construction toys—the lead designer used Working Model to conduct a detailed mechanism analysis.**

made in the past. First, a sculptor looked at drawings of the character and began to shape a 3D figure in clay or wax. Sometimes the job was complicated by the fact that the drawings weren't always consistent. A front view might depict the character with a longer upper torso than the rear view, for example. But sculptors were usually talented enough to overcome such obstacles.

The real drawback came when they took the sculpted figure to the licensor for approval. If it deviated from the look of the movie character by even a hair, they had to fix it. Worse, the licensor or even their own management might approve the look of the sculpture but decide it should be 20% smaller than what was originally asked for. This meant starting over. Once the sculpture was approved, it became the basis for the injection mold from which the toy was mass produced. This part of the process has benefited from the use of CAD and CAM for some time. In fact, it isn't that different from making any other injection-molded product (see "Toying with CAD" below).

The more recent benefits of using digital technology has come in speeding up the scuplting process. Consider a toy that Playworks recently developed from the Warner Bros. feature film, *Iron Giant* (see "Ten Ton Toon," pg. 36). Warner Home Video asked Playworks to create a small plastic replica of the giant that will be bundled with the videotape of the movie when it goes on sale. Playworks was given a DXF file of the Iron Giant CAD model, so rather than starting the process with a wax sculpture, it began with the digital representation of the giant.

There was a small glitch, however, that prevented Playworks from working with the studio's data exactly as received. Because of the stacking requirements for videotapes, the toy that Playworks was asked to produce could be only 3/4-inch thick. "The Iron Giant is a barrel-chested character, so one of the first things we

drives a vehicle onto its platform, the Down-A-Vator smoothly lowers the vehicle one level. Once the vehicle is driven off the platform, the Down-A-Vator returns to the up position.

The Down-A-Vator's mechanism, a four-bar linkage, was a critical design element because the platform had to remain horizontal while traveling though a very specific range of motion that allowed it to lower the vehicle and raise itself up again to exactly the right height. Moreover, Rokenbok didn't want any scissoring action that could hurt a child's finger.

It certainly would have been possible to design that four-bar linkage by hand. Engineers would have made a mockup of the mechanism with cardboard and push pins and fiddled with it until they got the motion they needed. Then they would have performed basic engineering calculations to determine mechanical characteristics, such as how much spring force was needed and where it should be applied to raise the empty platform back to its starting position. Additional calculations would have told them how much damping was needed so that the vehicle didn't drop too quickly to the lower level. "Engineers have made four-bar linkages without computers," says Dan Aldred, manager of product development at Rokenbok Toy Co. (Encinitas, CA). "But now it's easier and faster."

Aldred used Working Model from Knowledge Revolution Inc. to perform the mechanism analysis on the Down-A-Vator. At that time, Working Model was only a 2D program, so he actually started the entire design for the product in Working Model. He began by sketching out a 2D line drawing of the linkage, specifying which lines were rigid and which could bend, which line was a spring and which was a damper, and where the pivot points were located. He then specified the size of the spring and the damper and applied a 500-gram (17.5-ounce) load to the mechanism to represent the weight of the truck.

When he clicked "Play," the software ran the mechanism through its range of motion. Besides providing a clear image of the motion path, the software calculated the spring and damping forces and presented them in an easy-to-understand graph. Aldred could immediately see if the mechanism was performing as desired. "The beauty of doing it this way," Aldred says, "was that I could change the size of my spring or damper or the amount of the applied load and run the analysis again. It only took a few seconds for the computer to change the parameters and perform the calculations."

Aldred repeated the mechanism analysis until he had the Down-A-Vator's mechanism working exactly the way he wanted. He then used the final 2D sketch as the basis for modeling the rest of the product. Today, since Working Model supports 3D, Aldred says he would begin the design by creating a solid model in SolidWorks. He would include the pivot points, locations of the spring, and related information in the solid model, then use the solid geometry directly for the Working Model mechanism analysis.

This example involves a single mechanism on a single toy, but it saved Rokenbok one or two weeks of work, according to Aldred. Multiply that by all the toys with moving parts that are introduced each year and you can see what this software tool alone could mean to toy makers. In this industry, the full spectrum of design-automation technology is becoming a requirement. Taking advantage of technology has become the key to developing products that children will treasure, and delivering them at an ever-faster pace. —*Caren Potter*

## CAD TOOLS FOR TOYS

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had to do was take the data and compress it so that our figure was just 3/4-inch thick," says Curet. "In doing that, we had to make sure that he still looked like he's supposed to look."

Playworks imported the DXF file into 3D Studio Max, where an artist adjusted the giant's shape. "The program makes it easy to alter the scale of an object while keeping some of the original proportions," explains Brian Wilcox, head of the computer department at Playworks. "You can scale along one plane and keep the others intact."

After Playworks made a physical model of the toy on a ThermoJet 3D printer from 3D Systems. The object was then molded in silicone and cast in wax. Next, a sculptor refined the wax figure, and Playworks showed it to the client for approval. "Computer prototypes are a little stiff," explains Curet, "so it's still an industry standard to mold in wax."

One advantage of using a rapid prototype as the starting point for the wax sculpture is that it pretty much ensures that the design will be approved by the licensor. "We're using the actual character, not interpreting someone's else work, so when it comes to approval, it's correct," says Gentle Giant's Meyer. Another advantage is that once the digital model is available, it's easy to adapt to make additional toys in different sizes.

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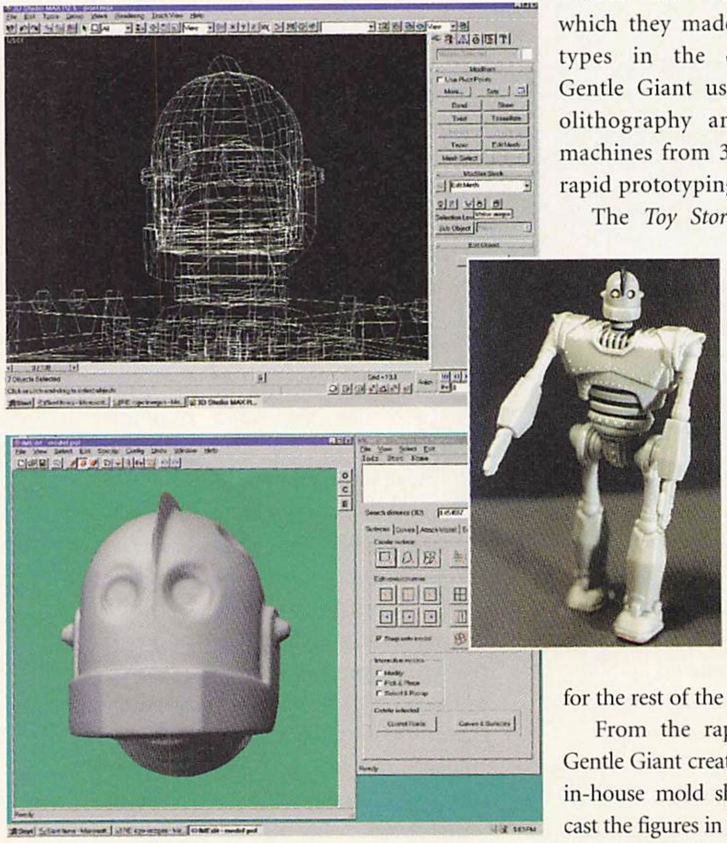
### Toy Story Toys

When a computer model of a movie character is available, as it often is these days, creating a digital model and rapid prototype prior to making the traditional wax sculpture is becoming the preferred process. Gentle Giant prototyped many *Toy Story 2* toys using this approach. Artists imported digital-animation data into Alias|Wavefront's Maya, where they posed the characters in the shapes they wanted for the toy. A "Woody" bank might have a different pose from a "Woody" cup topper, for example. Or, a toy might have two characters posed together, such as Woody and his horse, Bullseye.

Once the artists were happy with the posed figures, they converted the Maya models into STL files from which they made rapid prototypes in the desired sizes. Gentle Giant uses both stereolithography and ThermoJet machines from 3D Systems for rapid prototyping.



Sculptors at Playworks imported a CAD file of the Iron Giant into 3D Studio Max (above) and created a flatter toy replica (above right) to fit packaging specifications.

The *Toy Story 2* characters were then hand-finished because, Meyer says, "the level of finish from the RP machines is not as smooth as glass, and we want these to look good because they form the basis for the rest of the process."

From the rapid prototypes, Gentle Giant created molds in the in-house mold shop so it could cast the figures in its own working wax. Hand finishing was required here, too, to bring the wax models "to a pristine state that lends itself to better tooling." The last steps, once the wax sculptures were approved, were to cast them in hard urethane resin and meticulously hand-clean them to produce tooling-quality master prototypes. In this way, Gentle Giant was able to create more than 100 *Toy Story 2* toy prototypes for its client, Thinkway Toys, in a matter of weeks.

### Replicating Real People

What happens when the character is a live actor, and there's no digital model of a movie character to start the toy-making process? The lack of a digital file is not a problem for Gentle Giant. The company can create a maquette, a small model that licensors distribute as a style guide, using a Cyberware 3030 high-resolution laser scanner. The point-cloud data that comes from the scanner is surfaced using the company's proprietary G-Sculpt software. From there, the model goes to Maya to be sized and posed, and the rest of process unfolds as described above.

Among the companies that produce toy prototypes from recognizable characters, there seem to three different philosophies. One, represented by Gentle Giant and Playworks, is to use digital technology publicly, so that it becomes the industry norm. "It's best to embrace the technology and be associated with the forefront," says Meyer. Another tactic is to use digital tools but keep them secret, in hopes of maintaining a competitive advantage. In fact, that camp is represented by several companies that asked not to be mentioned. The third strategy is to continue to do things the old way. This one reminds me of manufacturing companies that insisted for years that they did not need CAD. I wonder what they're doing today.

*Caren Potter is a contributing editor of* Computer Graphics World. *She can be reached at cpotter@northcoast.com.*

Old Penn Station, by David Beker (3D Studio MAX)

# Real or REALimage®?

**Artist David Beker** used 3D Studio MAX to create this incredible, photo-realistic scene. Like other CG artists and designers, David is constantly pushing the limits of technology to produce images that make it difficult to distinguish between what's real and what's rendered.

*"I wanted to recreate Penn Station in 3D so people could experience that incredible space. I wanted people to be able to move through it and appreciate what it must have been like to be there. No other medium could come closer to recreating that feeling."*

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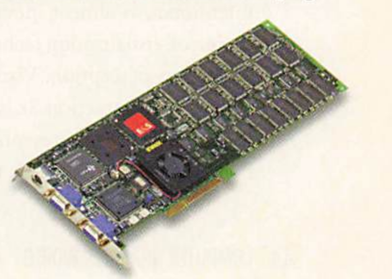
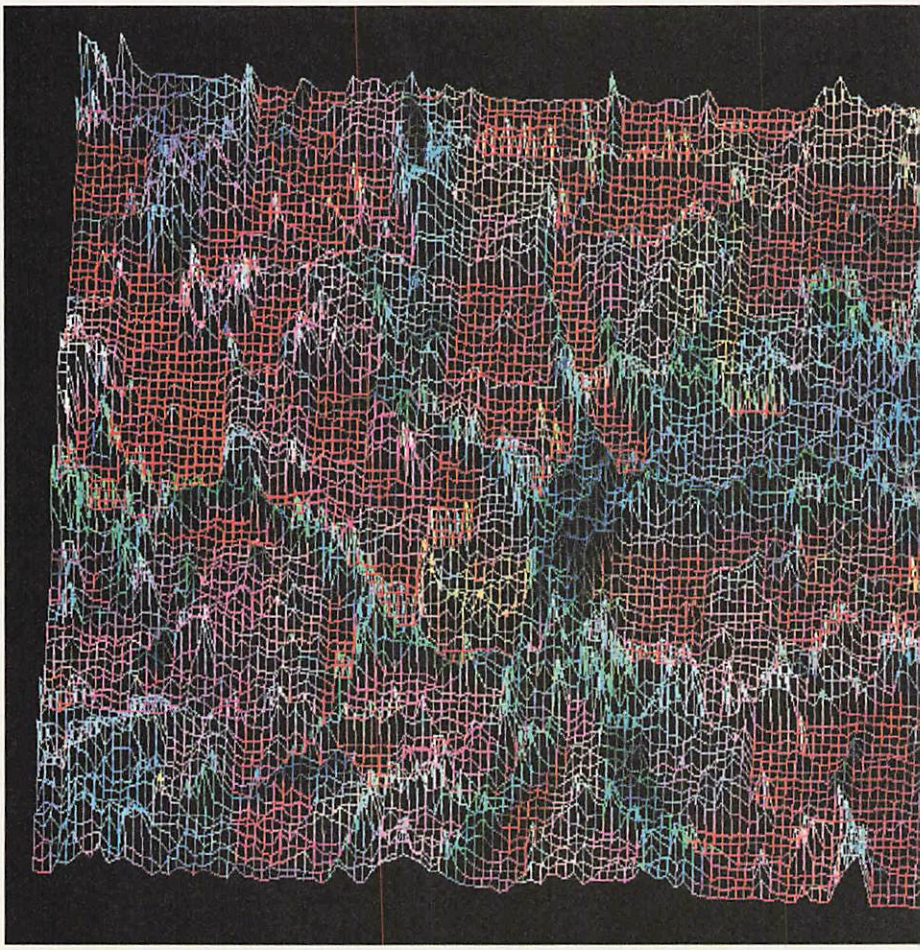


# the picture of uncertainty

RESEARCHERS ARE EMPLOYING A RANGE OF COMPUTER GRAPHICS TECHNIQUES TO DEPICT THE UNCERTAINTY IN THE VISUALIZATION OF COMPLEX DATA

BY DIANA PHILLIPS MAHONEY

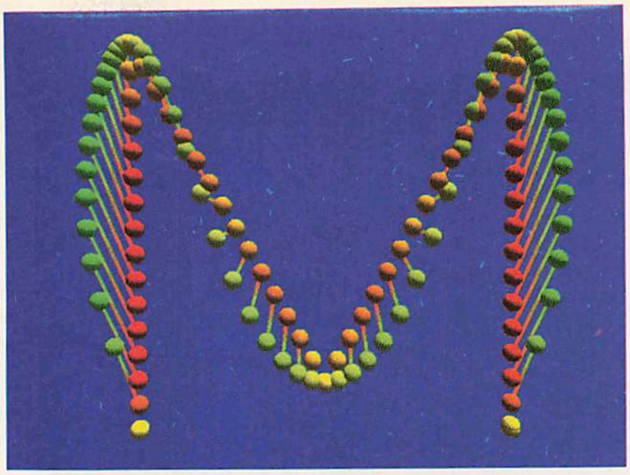


**A wireframe surface depicts the areas of uncertainty in a visualization of terrain distinctions in a region of West Australia. The red and blue areas represent crops and remnant vegetation, respectively. The visualization is based on Landsat data.**

Seeing is believing. In computer visualization, seeing is also understanding. It is looking at a visual image, processing its components, and learning more about it than if it were to be described in words or numbers. But what if the picture we're seeing—the one we're believing and think we're understanding—is a misrepresentation? What if the image doesn't tell the whole story or, through lies of omission, tells a misleading one?

Such deception, while not necessarily intentional, is almost inevitable given the nature of visualization technology and that of human perception. Visualization, at its core, is an abstraction. It is a way to put a face on numbers representing phenomena that are complex enough to require such treatment. Indeed, the process through which numbers are gathered, transformed, and ultimately displayed visually can be fraught with uncertainty.

For example, in a geological application, "sampled" data collected to understand the distribution of elements in the soil can only ever be an approximate representation of



**Animated sphere glyphs are among the visualization tools UCSC researchers use to show spatial and temporal data uncertainty. The spheres highlight uncertain data. Animating them shows the variation over time.**

the soil distribution across the region of interest. It would be impossible to get measurements for each and every point in the sample. Thus, visualizing the data involves making assumptions about the points that have not been measured, and representing those assumptions graphically.

The same goes for the visualization of dynamic information. To represent atmospheric changes over time, for instance, data may be gathered at a series of sequential points or time steps. What happens between these points can be assumed or predicted, and visual interpolations can made on that basis, but unless measurements exist for the activity of variables at every time step, the resulting visualizations contain uncertainty.

Geospatial applications are particularly vulnerable to uncertainty, since graphic "reality" is not absolute reality. It is an approximation of reality based on geographic features (typology, location, spatial relationships) observed at many points across a landscape. Because it doesn't incorporate measurements of every point in the region the ultimate map is to represent, it is an uncertain reality.

Image courtesy of Mark Gahegan, Penn State University.

Uncertainty in this sense should not be equated with "method-produced," or measurement error, says Barbara Buttenfield, a University of Colorado geography professor and uncertainty researcher. "The issue is not only one of measurement, but also of the discretization of measurements, of digitizing a continuous reality."

Geographical visualization is not the only victim. Uncertainty is encountered in the representation of nearly all types of complex scientific and numerical data, including visualizations of molecular and computational-fluid dynamics, medical imaging, bioinformatics, and multidimensional financial information. While the existence of uncertainty doesn't necessarily negate the information value of a given visualization, an awareness of it is critical to obtaining a clear view of the data. Such information could impact the interpretation of the visualization and subsequent judgments based on that interpretation.

## The Role of Uncertainty

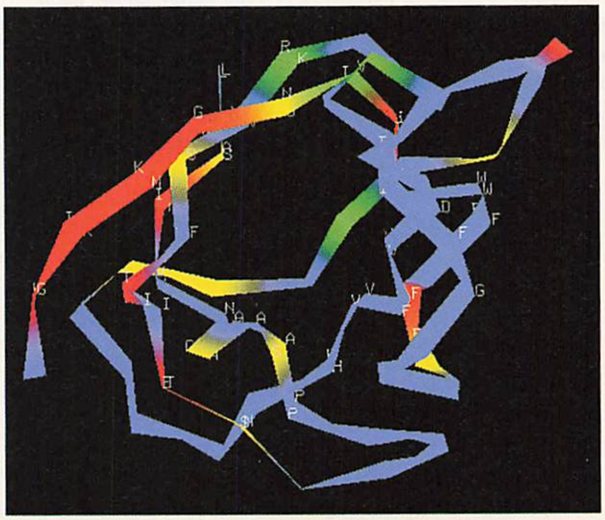
Despite its importance, uncertainty visualization has hardly been given the attention it deserves. "People tend to believe what they see in visual representations, and quite often those representations are not immediately backed up by the numerical information that tells them when to be cautious," says Alan M. MacEachren, a geography professor and director of the GeoVISTA Center at Penn State University.

One reason for this might be the fear that doing so may lesson the impact of the visualization itself by making it confusing or causing it to be perceived as suspect. Another reason is that it makes a less dramatic picture. People crave clear boundaries, distinct beginnings and endings, smooth transitions. Because we respond to clear, sharp images, we're impressed by isosurfaces that smooth what should be fuzzy edges and by structures with distinct, bright colors where muted color transitions would be more accurate.

As visualization technology becomes more pervasive, however, hiding uncertainty under flashy pictures becomes increasingly onerous. "It's more important than ever to somehow embed uncertainty into the visual display, especially when people are making important decisions based on these displays," says MacEachren. For example, geographical information systems are used extensively in applications such as environmental management and national security. Policy makers in these areas can only make informed decisions if they know to what extent the underlying data is uncertain.

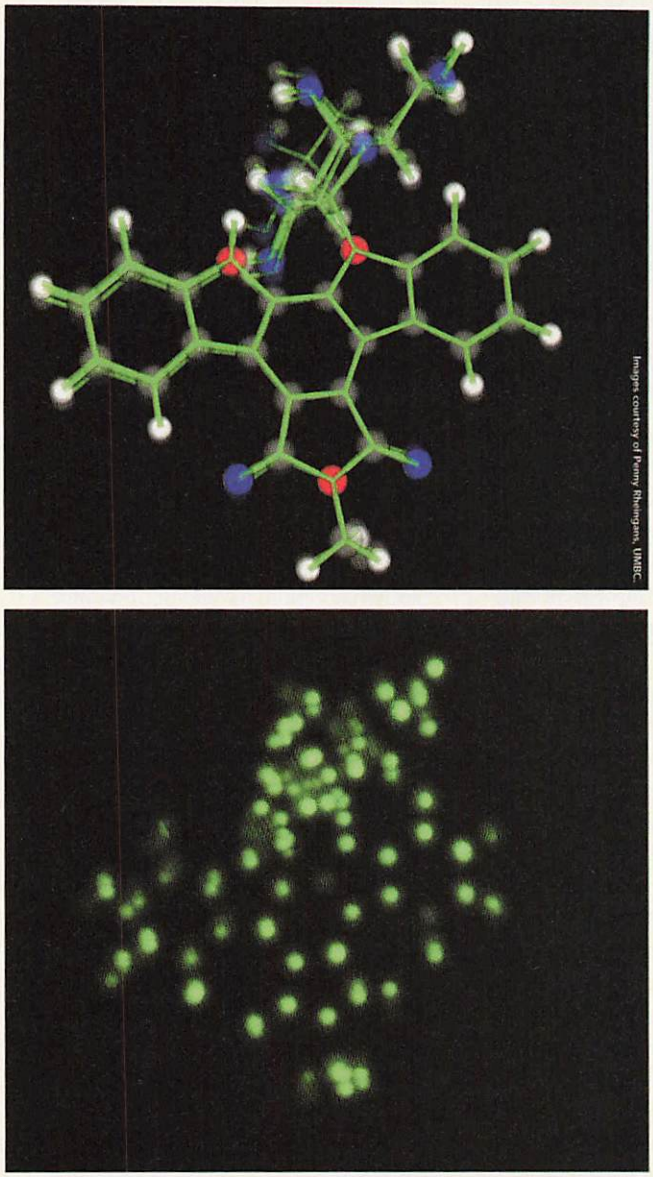
Similarly, in a medical application, a physician making treatment decisions based on data obtained through a medical visualization must be made aware of the degree of confidence associated with the images in order to provide proper care.

Before uncertainty can be visualized, it



**Comparative visualization techniques help genetic researchers understand the "fit" between gene sequences and protein structures. In this image, UCSC researchers link Lego-like glyphs to represent amino acid components. Traditional techniques such as color-mapping and side-by-side comparisons help identify areas of uncertainty.**

has to be identified, then quantified. And the quantification process itself is an uncertain one. The values are generally discerned from a model of likely realities developed using one of any number of statistical techniques, such as Monte Carlo simulations. These involve simulating enough possible datasets to get an estimate of the potential distribution around some mean value. "Once you have those techniques developed, the measures are fairly well accepted," says MacEachren. "The next step is harder—deciding how much uncertainty is too much for a particular application. Acceptable levels will vary across disciplines, just like statistical confidence intervals in medicine are usually much narrower than they are in the social sciences."


Images courtesy of Penny Rheingans, UMBC

**An awareness of the spatial uncertainty of molecules is critical to effective drug design, which involves fitting the molecules of a given medication to the active site of treatment. If either or both of these elements are dynamic, there may not be a single correct fit, but rather a series of likely fits. The top image shows eight possible drug configurations of an anti-tumor medication, each with opacity determined by the likelihood of that configuration. More opaque regions represent a higher likelihood of an atom occupying that location. The bottom image shows a volume rendering of the composite space of the likely positions over time.**

What is also application-dependent is the determination of how to represent uncertainty data within a visualization. "The challenge here is figuring out how to incorporate uncertainty features into data displays in a way that is natural and intuitive in a given application, without increasing the visual complexity," says Alex Pang, a visualization researcher at the University of California at Santa Cruz (UCSC).

To this end, Pang and his colleagues have developed a broad range of visualization methods for combining data with uncertainty information in specific applications. These include vector glyphs to visualize uncertainty in certain types of flow simulations, a tool for interactively visualizing distortion in map projections, a system for comparing different fluid-flow representations, and a method for depicting uncertainty in DNA and amino acid sequences and protein structures. The researchers are currently implementing the latter to help scientists involved in the Human Genome Project visualize the quality of the fit between gene sequences to protein structures.

The UCSC researchers have also developed an application-independent visualization method called the reconfigurable disk tree (RDT). The RDT uses a setup of links and nodes that can be rearranged to organize and display hierarchical spatial and non-spatial (such as financial or statistical) data, including the relevant uncertainty information.

To enhance the user's perception of uncertainty, each of these methods relies on such visualization techniques as side-by-side viewing, pseudocoloring, transparency, texture, and animation.

## An Uncertain Picture

Although most researchers agree that there is no one "best" way to visualize uncertainty, a number of general perceptual considerations can help guide the process. "You first have to think about how important it is to get across uncertainty in a particular application. If critical decisions lie in the balance, where you shouldn't be making the decision in the face of uncertainty over a certain level, then you probably want to visually obscure the data—maybe make the uncertain data change into a background color, so the certain information is prominent. This way it's not possible for someone to make an incorrect assumption," says MacEachren. "In applications where people just need to be able to second-guess their decisions, maybe to make sure they're not going out too far on a limb, it's important to let them see the patterns first, and then think about how certain or uncertain they are." In such a scenario, the uncertainty representation could reside in the background and be accessible when needed.

The key, MacEachren notes, is to clearly separate the data and the uncertainty. In an application he and his colleagues developed to visualize the surface pressure predicted by meteorological models, the pressure visualization and the certainty prediction were separated graphically. "We used isobars, lines of equal barometric pressure, to represent pressure, and we used an area-shading scheme to depict the uncertainty. We then animated the result. An interesting outcome was that it made the fact that the models disagreed more in time than space quite obvious," he says. The results were important in terms of the ability to predict when a pressure system would reach a certain region.

Another consideration in designing an uncertainty visualization is human intuition. "We have expectations about what uncertainty means. It's where the colors get dim, or

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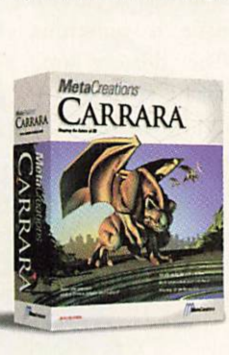

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where things get fuzzy or fade out. It makes sense to take advantage of those expectations," says Penny Rheingans a visualization researcher at the University of Maryland Baltimore County.

One of Rheingans' areas of focus is the creation of "likelihood" visualizations for biomedical applications. In a recent project, she worked with a medical researcher developing an anti-tumor drug. "The effectiveness of the drug was dependent on how it fit geometrically into the active site. One part of the drug molecule was connected by a single side chain and moved around a lot. The 'likelihood space' of the composite shape based on this movement was going to affect how it would fit," she says. "You could take a snapshot of the molecule at an instant and maybe it would fit well, but if that instance was unlikely, it might not be an effective drug." In order to view the range of what the molecule could look like, the researchers built a model based on an average of a number of possible configurations. They created a visualization to depict the likelihood of a geometric fit with respect to the molecule's movement over time.

Such an approach is more challenging when the uncertain values are ambiguous. For example, Rheingans and her colleagues recently began working with doctors at Johns Hopkins Medical Center on a method to show the likelihood that a particular tissue is cancerous. "The doctors are looking at tumors in the liver. They have a model that says the signal response [from an MRI] at a particular level is likely to be tumor or healthy tissue. The problem is that around the periphery of the tumor there are values somewhere between the two levels," she says. The researchers' objective is to visualize the tumor and partial-tumor zone by using variations in color and opacity to depict the degree to which given voxels represent healthy and diseased tissue.

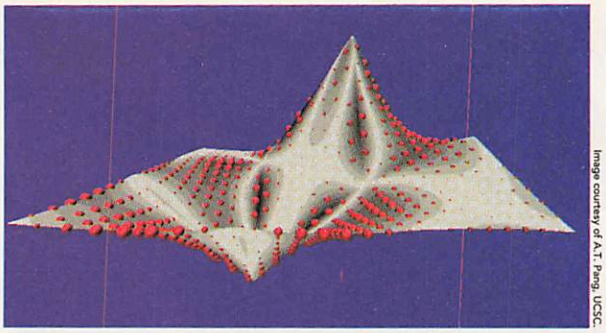
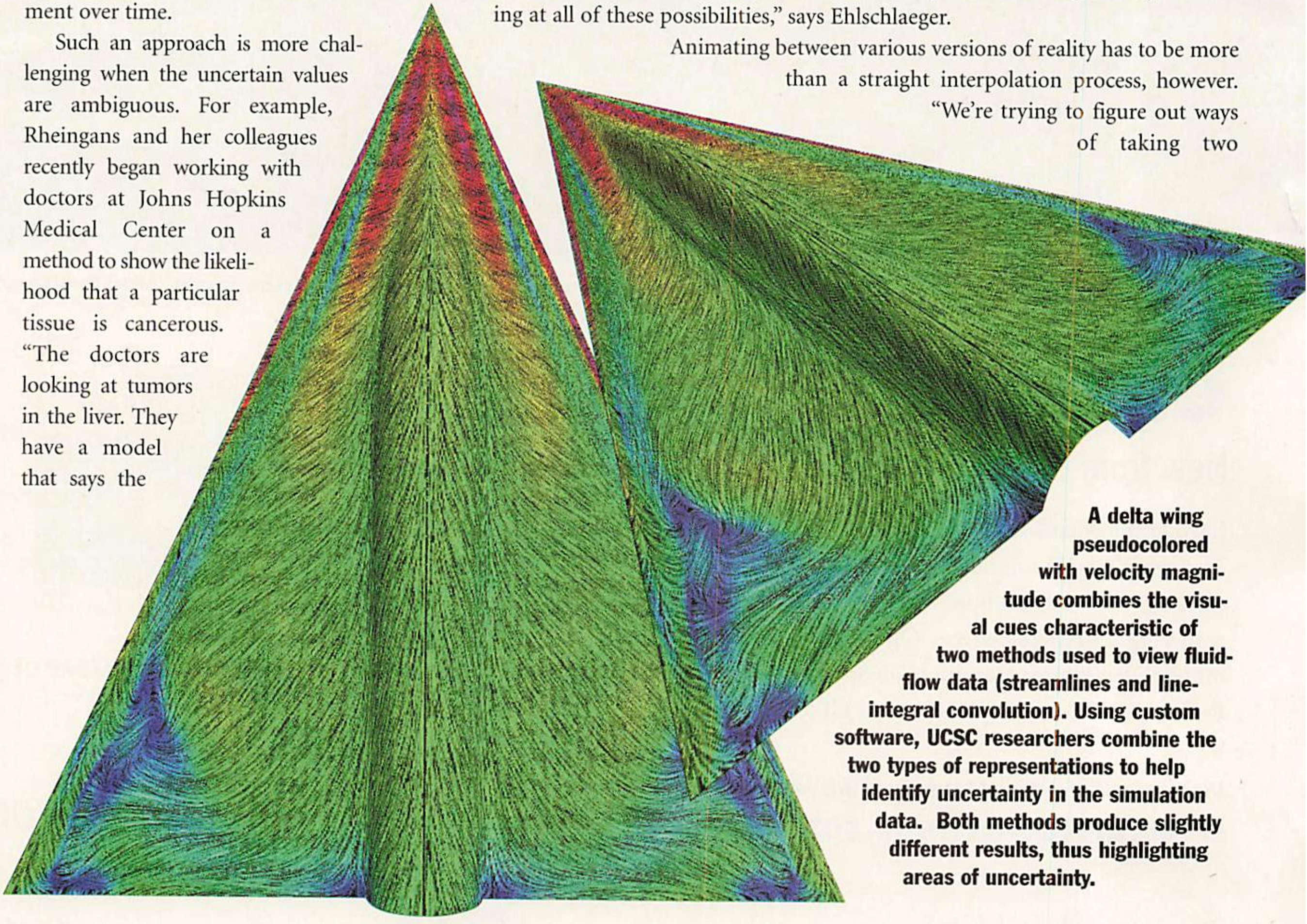


Image courtesy of A.T. Pang, UCSC.

**Mapping uncertainty to pseudocolors and glyphs offers an intuitive way to understand the quality of complex data. The size and color of the spheres represent such characteristics as the amount of uncertainty and its variation over time.**

Another way to demonstrate uncertainty in a dataset is to map an appropriate range of possible realities and animate the results, says Chuck Ehlschlaeger, a researcher in the geography department of New York's Hunter College. Ehlschlaeger is researching techniques for doing this using surface-elevation data. "The goal is to ask a question and determine a range of possible answers, then link the still images representing each possible result into an animation," he says. Such an approach not only helps researchers explore large amounts of data that couldn't be represented in a single, static view, but also provides an understanding of the effect of uncertainty in the application. "If, for example, someone has to decide whether or not to allow development in an area where an endangered species is at risk, we need to come up with a mapping of possible realities that is large enough so that the 'real' reality likely falls within that distribution. Then we have to come up with some logical way of looking at all of these possibilities," says Ehlschlaeger.

Animating between various versions of reality has to be more than a straight interpolation process, however. "We're trying to figure out ways of taking two



**A delta wing pseudocolored with velocity magnitude combines the visual cues characteristic of two methods used to view fluid-flow data (streamlines and line-integral convolution). Using custom software, UCSC researchers combine the two types of representations to help identify uncertainty in the simulation data. Both methods produce slightly different results, thus highlighting areas of uncertainty.**

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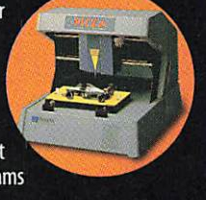

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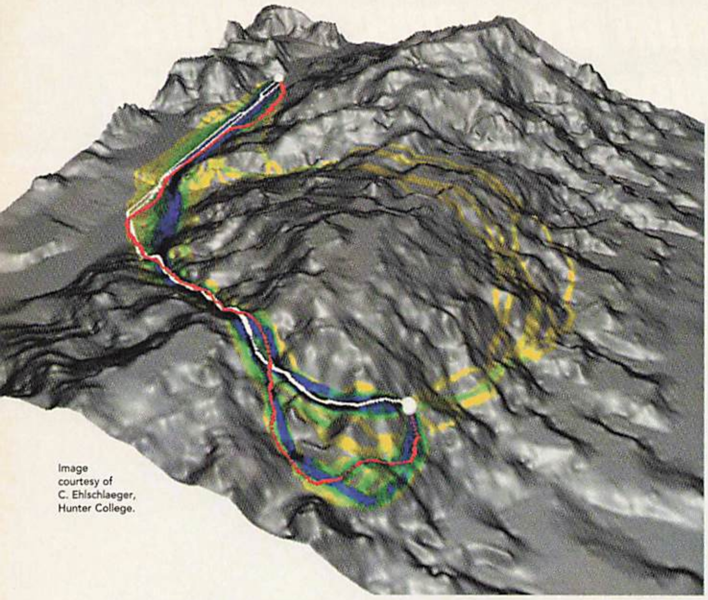
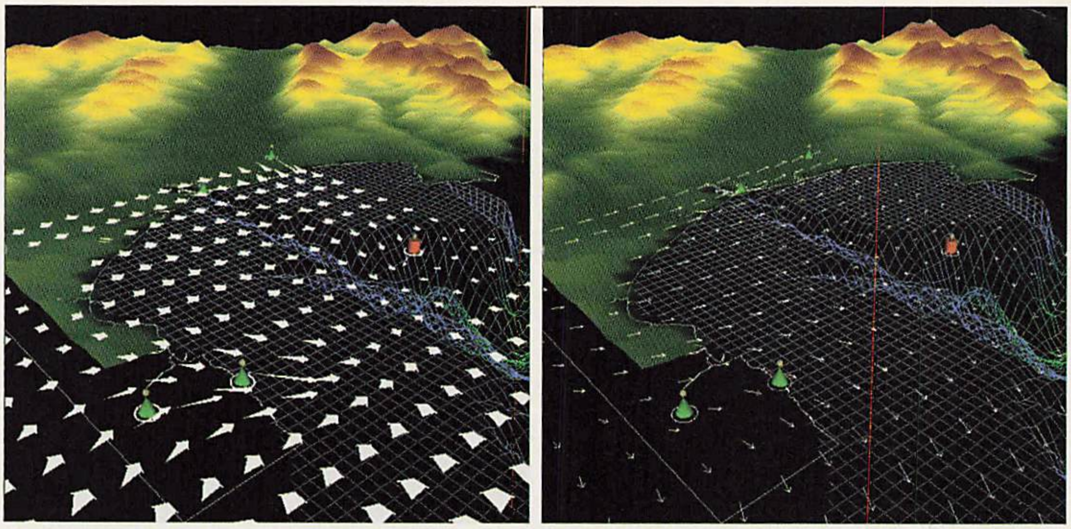


Image courtesy of C. Ehlschlaeger, Hunter College.

**Uncertainty models can be used to simulate potentially optimal routes between two points and the results can be visualized to make clear such distinctions as the shortest or least-expensive route. This image contains data for 250 potentially optimal paths between two points. To avoid visual clutter, each of the colored paths represents a group of closely aligned optimal routes.**

versions of reality and morphing between them, while at the same time making sure that the morphed images have the mathematical characteristics of what could be reality," says Ehlschlaeger. This approach is not applicable across the board, however. For example, it's less useful where adjacent potential reality stills are very different. "Imagine setting up a camera in Times Square in New York, and taking one picture every hour, then displaying the series of pictures as a 30 frame-per-second animation. You wouldn't see anything specific, because each frame would be so different."


**Vector glyphs can illustrate the continuous range of data quality in environmental vector fields. Here, UCSC researchers used them together with traditional arrow glyphs to show uncertain wind and ocean currents. The uncertainty is depicted in direction and magnitude, as well as mean direction and length.**

Some applications require not only that uncertainty data be visible, but that it also be highly interactive. This is the case at HRL Laboratories in Malibu, California, where researchers are developing methods for visualizing uncertainty in tactical data in order to determine the effect on a military commander's ability to make decisions. "We depict uncertainty in two ways simultaneously. A 'situation awareness' visualization shows the uncertainty associated with a specific object, such as an aircraft flying over a terrain. At the same time, we display an abstraction of the [commander's] evidential reasoning network, based on the aircraft's attributes and the uncertainty associated with them," says HRL researcher Pete Tinker.

The resulting "belief" visualization is dynamic, interactive, and animated. "A user can navigate through the network to determine sources of uncertainty and can drill down at any point to get more detail," says Tinker. This is critical if a military commander is to use the tool to get a clear understanding of data uncertainty and its underlying causes. "[Such information] can mean the difference between action and inaction, life and death."

Although uncertainty modeling isn't new, the push toward visualizing it is fairly recent. Because of this, much of the code being developed to handle it is either fully custom or developed using low-level programming capabilities of shareware visualization software or commercial toolkits, such as Data Explorer from IBM (White Plains, NY) and AVS from Advanced Visual Systems (Waltham, MA). Recently, many researchers have begun writing their applications using Sun's Java 3D API, citing the benefits of platform-independence and the easy production of Internet-ready data. "Java is well suited to some of the ways we specify which parameters of a display should be controlled by the user," says MacEachren. "And it provides a flexible method for representing temporal data, which is important to the work we're doing."

While the technical challenges involved in the development of uncertainty visualizations are significant, the more daunting obstacles may be the conceptual ones. "We understand so little about the nature of error and how to formalize our descriptions of uncertainty. Additionally, we understand little about how humans deal cognitively with uncertainty," says Barbara Buttenfield. "It's difficult to automate or mechanize something that is not completely formalized. So without formal models of uncertainty, its detection, identification, and analysis are all impeded."

A related obstacle is figuring out how to get people to make decisions in the face of uncertainty, says MacEachren. "Decision makers often don't like to know anything about uncertainty. Our challenge is to find ways to present the information so they can and will incorporate it into their decision-making process."

*Diana Phillips Mahoney is chief technology editor of* Computer Graphics World.

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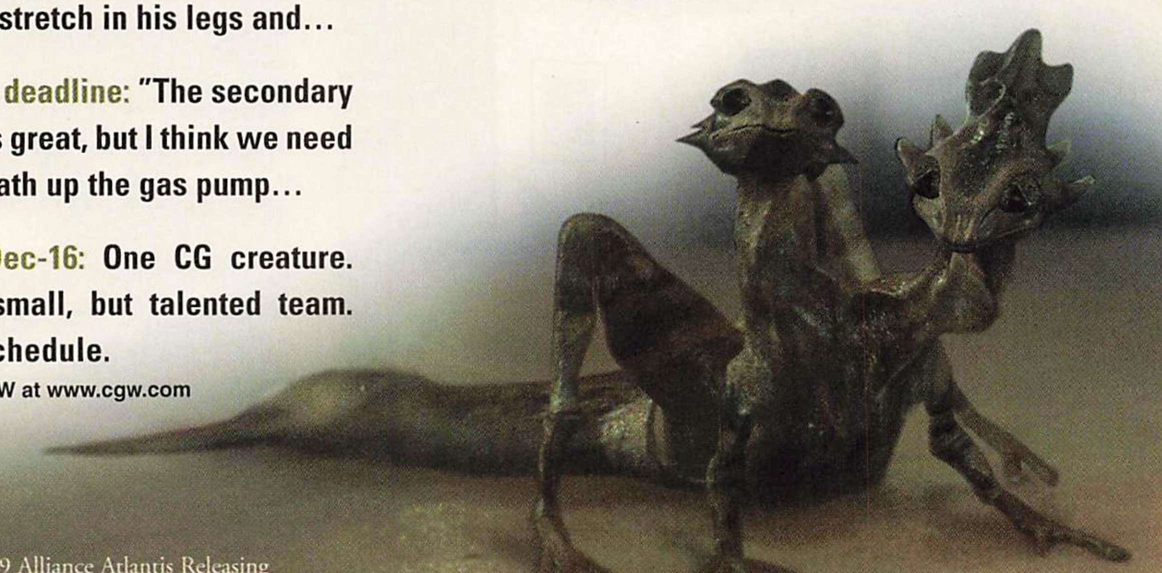


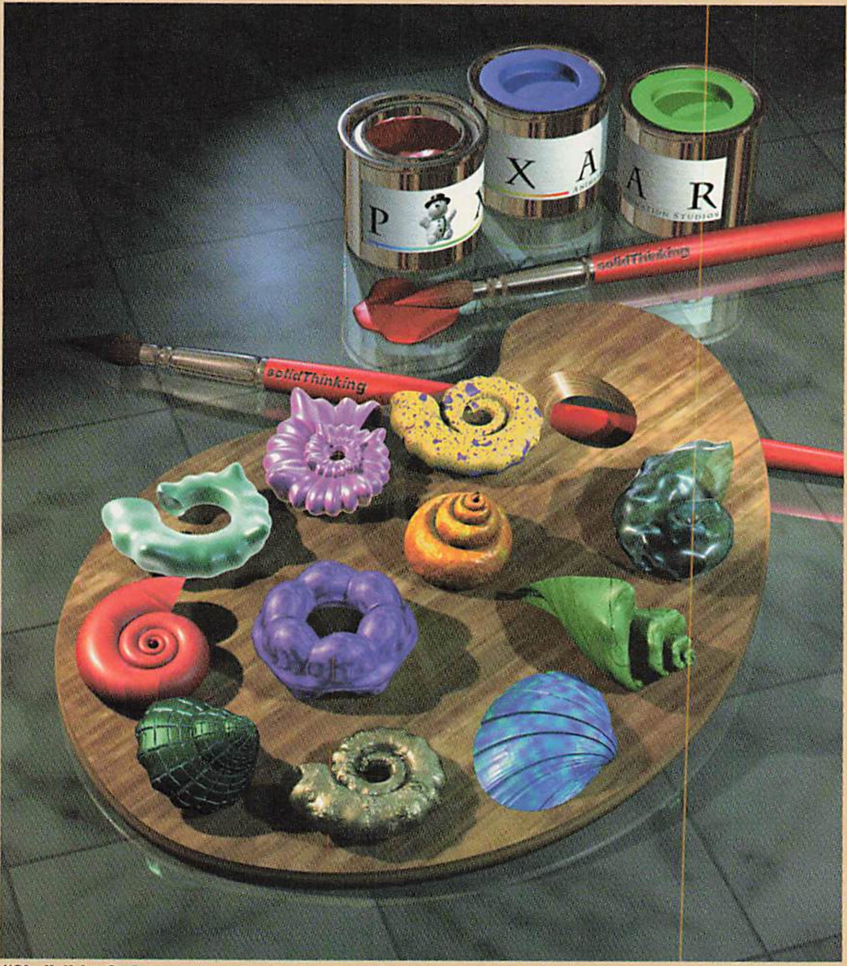
eXistenZ image ©1999 Alliance Atlantis Releasing

# Product Galleria

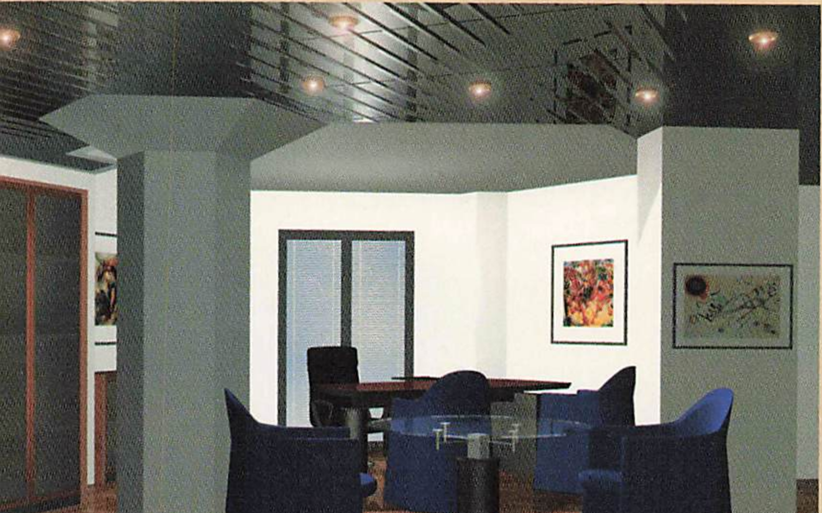
Product designers can no longer focus on the mere physical attributes of their creations. To compete in today's market, they must produce captivating styles and display them in settings that evoke positive feelings from potential buyers. So adept are some industrial designers at creating an "image" for their products that their presentations now resemble works of art.

In recognition of this trend, Gestel (Vicenza, Italy) hosted an image contest, soliciting innovative works from users of its SolidThinking 3D modeling and rendering tools. Some of the winners—along with more recent works created with SolidThinking 3.0—are displayed on the following pages. All the images have been created entirely with SolidThinking's NURBS-based modeling and scan-line, raytracing, and radiosity rendering techniques. The exception to this is "Shelly," which was rendered with Pixar's (Pt. Richmond, CA) RenderMan.

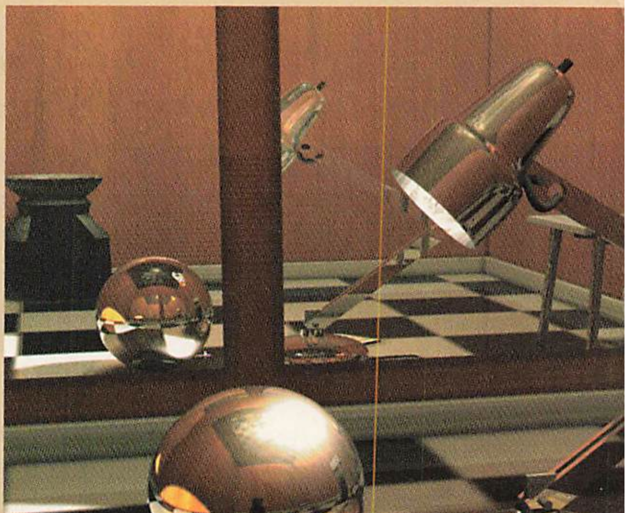
To view these product stylings, visit SolidThinking's Web gallery at www.gestel.it/Products/solidThinking/Image_Gallery/image_gallery.htm. —*Karen Moltenbrey*



**"Shelly" by S. Amoroso**

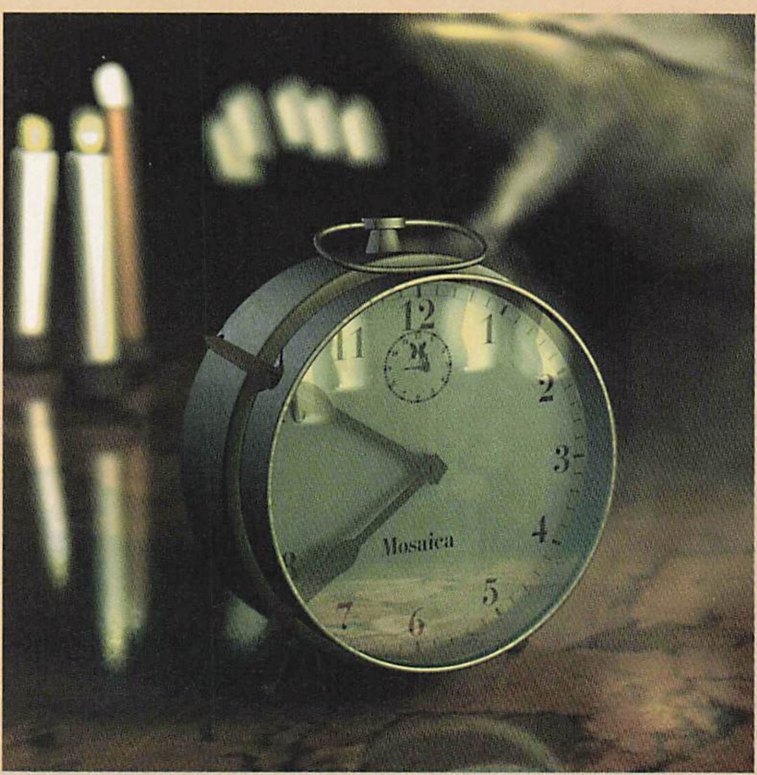


**"Room" by Adel Matar**

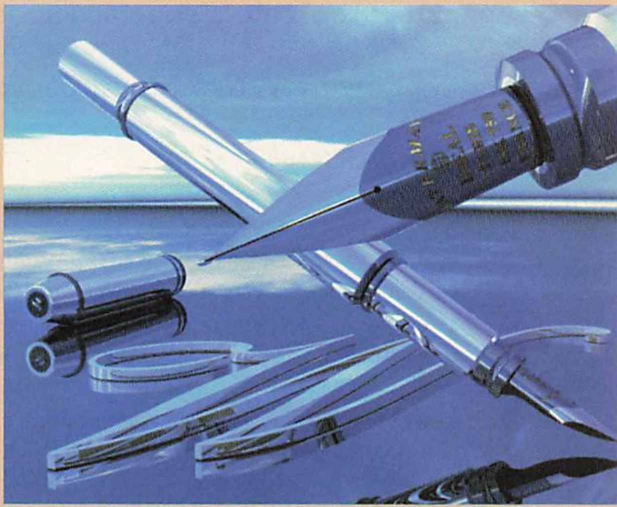


**"Curious Lamp" by Chris Stegner, Shattered Light Productions**

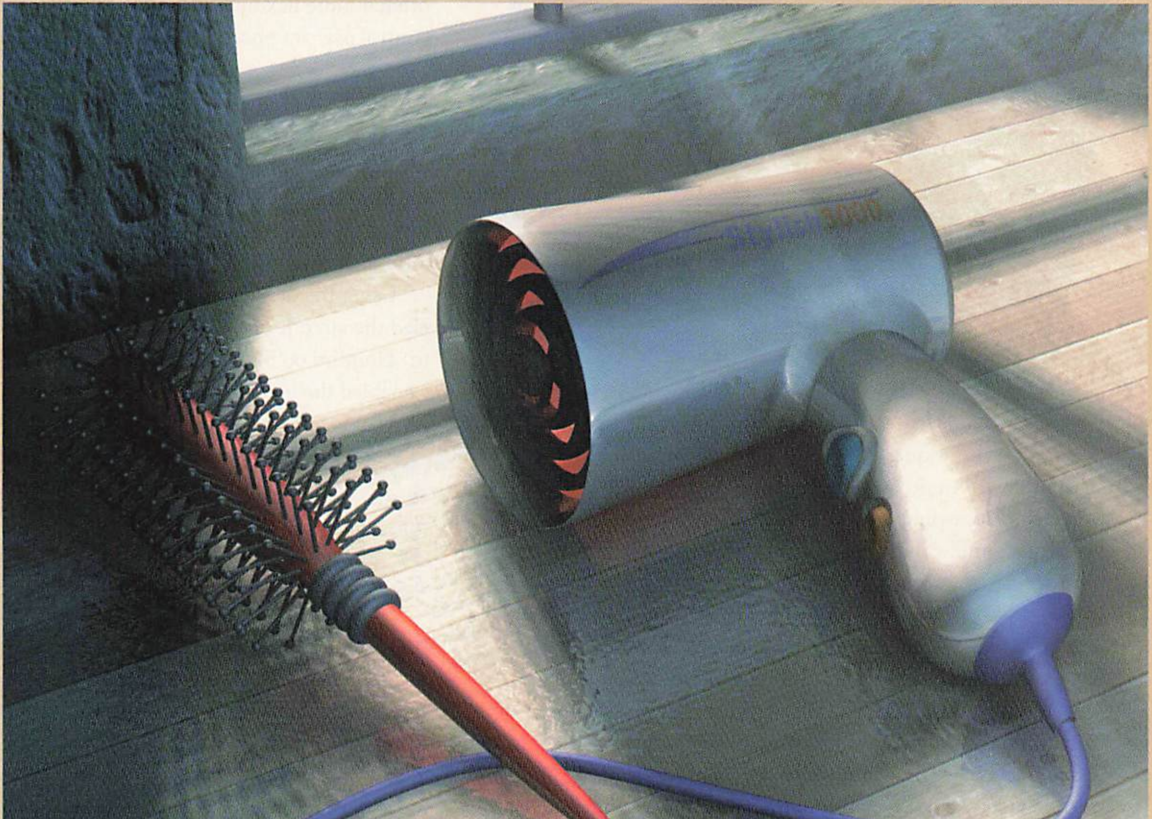
# FOLIO



"Vita e Memoria" by Gianmarco Ferraro



"Fountain Pen" by Vincent Courtois, Austral Design



"Hairdryer" by Pixel Art

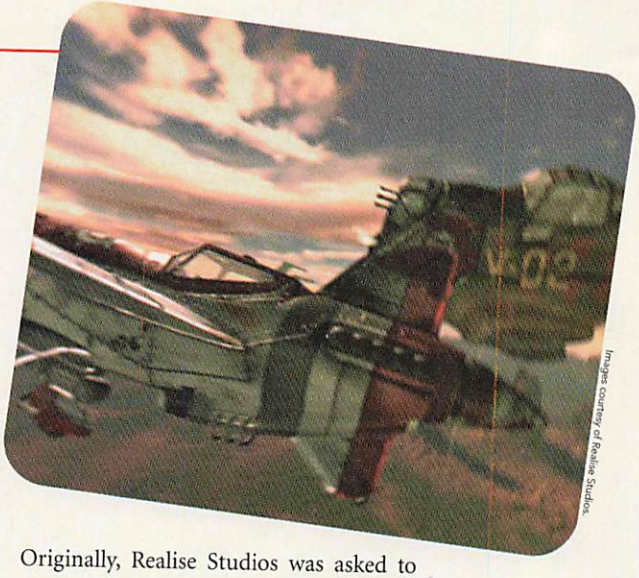
# SOMETHING "SPECIAL"

## Animators replicate a spectacular aerial dogfight over a virtual Grand Canyon

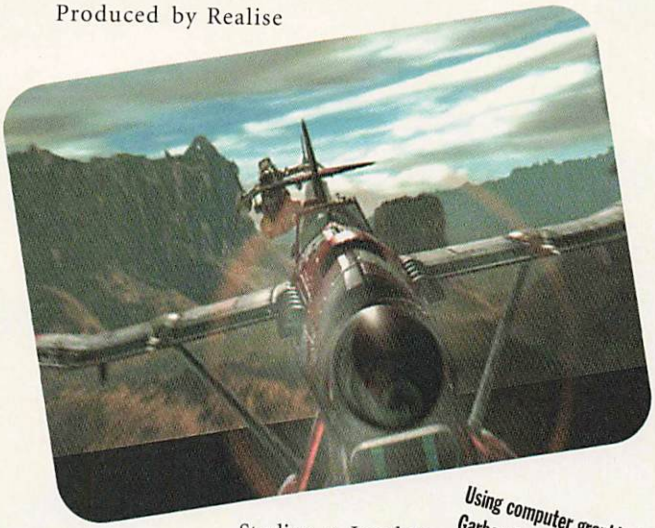
BY KAREN MOLTENBREY

The simulated aerial dogfight between two World War II fighters dangerously weaving through the Grand Canyon serves as an exciting backdrop for the music video "Special" by the rock band Garbage. The chase would have been far less thrilling, however, without the use of computer graphics to create the daring moves through the Canyon's most dramatic rock formations—stunts that would have grounded even the most seasoned pilots, let alone Garbage's lead vocalist Shirley Manson, who "pilots" one of the planes. In fact, the simulation was so successful that the video won a 1999 MTV Award for Best Special Effects Music Video.

Produced by Realise Studios, a London animation boutique, "Special" contains more than 70 multilayered shots of photorealistic sprawling terrain and mesas, azure sky and clouds, and a majestic Southwest mountain range. "What makes this video unique is the huge amount of computer graphics that isn't obviously CG," says Paul Simpson, animator and founder of Realise Studios. Making this project more of a mountain than a molehill was the fact that only two full-time and three freelance artists completed the 9000 frames of CG required for the video in fewer than seven weeks. "It was an incredibly huge job for a company of any size," he notes.



Images courtesy of Realise Studios.



Using computer graphics helped catapult Garbage's "Special" video to new heights. By modeling the Grand Canyon in 3D, the artists were able to outdo Mother Nature by building far more dramatic cliffs and rock formations for the background. Digital technology also enabled the pilots to achieve stunts that would have been much too dangerous to attempt otherwise.

Originally, Realise Studios was asked to model and animate only the planes, which were to be composited into live footage of the canyon shot from a helicopter. But after the artists presented a small, 100-frame test of what could be accomplished by digitally re-creating the landscape, there was no question that computer graphics was the way to go. "Computer graphics enabled us to achieve a high degree of realism. When they saw the sample, they didn't know whether it was real or CG. But it offered more flexibility than live action by giving the director total control over the choreography as well as the scenery," Simpson says.

### Modeling Job

To achieve the unique retro/modern look the director was seeking for the planes, Simpson hired an artist to create 2D sketches of the aircraft. Then he and partner Stuart Gordon visited a local museum to view vintage aircraft, "so we could make the [CG] planes look distressed and dirty, as if they've been flown for many years."

Using the designs and research, freelancer Dayne Cowen modeled the aircraft procedurally using Side Effects Software's (Toronto) Houdini on SGI (Mountain View, CA) O2s and Indigo2s. This enabled the team to add or delete detail as needed, depending on the location of the planes in relation to the camera, which "sped up the process dramatically," Simpson says, "leaving time at the end for the director to make last-minute changes."

For animating the objects, the group primarily used keyframing, while Houdini and Houdini's CHOPS were used for the secondary motion of the planes' rolling, pitching, and yawing. CHOPS enabled the artists to cut and paste motion, "almost like editing film footage on an Avid [nonlinear digital film/video editor]," remarks Gordon, who performed a large share of the animation. The team also used CHOPS to automatically control the airplane's flaps and gauges during movement. "All we had to worry about was moving the plane from Point A to Point B," Gordon says, and all the secondary objects of the plane (flaps, wheel, gauges) automatically moved to follow the action. "It's similar to animating a car turning a corner, where you move the car and the steering wheel and tires turn automatically."

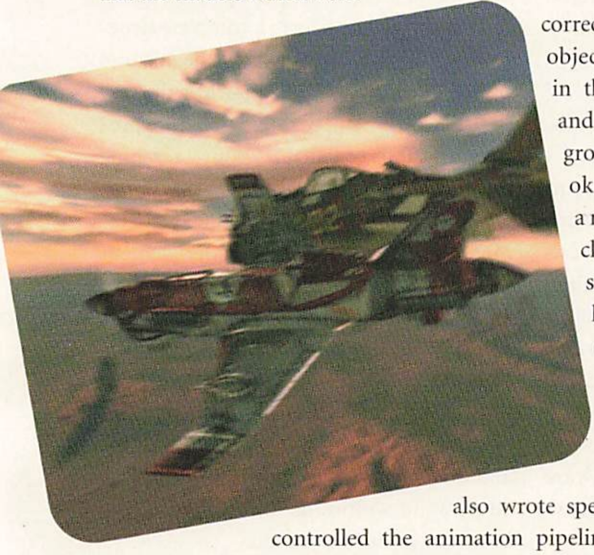
To produce the gunfire effects during the aerial chase, the group used Houdini's POPS procedural particle system.

The landscape—a CG interpretation of the Grand Canyon and Monument Valley, Utah—was also modeled from scratch in Houdini. The flat portion of the terrain was procedurally generated with fractals, while the mesas were constructed with a landscape instruction kit, developed in-house with Houdini's procedures and routines. The artists were then able to model and move at will 300 square miles of simulated billion-year-old rock formations to make the scenery and shots even more dramatic.

## Made in the Shade

While Adobe Systems' (San Jose, CA) Photoshop was used to create some texture maps, most of the texturing and shaders were made procedurally in Cinema Graphics' (Chatsworth, CA) ShadeTree, with some customization by Realise Studios to push the shaders even further. Rendering was done using Pixar Animation Studios' (Pt. Richmond, CA) RenderMan on custom-built hardware running Linux. "ShadeTree enabled us to capitalize on the power of RenderMan without having the expense of a programming team writing shaders for us," says Simpson. "This helped us to achieve the film-like quality we were seeking, instead of the plastic look that often results from using CG."

However, to obtain the desired look required Simpson to write customized code. For instance, the animator scripted commands so that the shaders would work correctly when the objects were both in the foreground and in the background. "They're okay when you are working close up, but the shaders didn't look great for objects that were fairly far away," he explains.

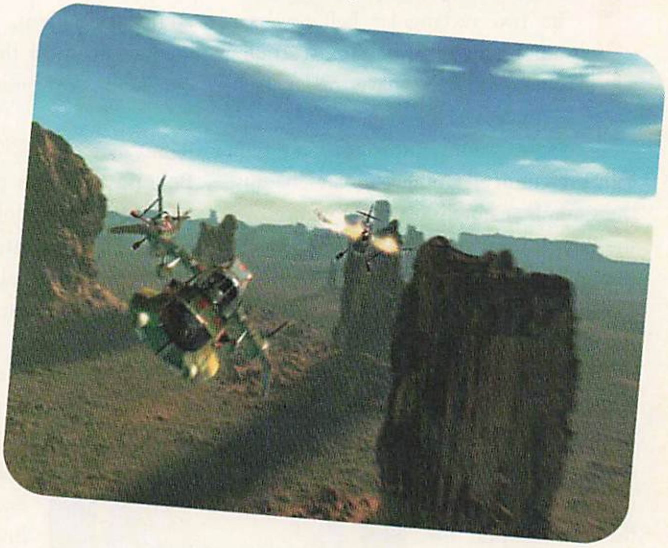


Simpson also wrote special code that controlled the animation pipeline and "glued everything together." This was necessary because the animation and modeling had to be worked on in parallel due to the time crunch, and it helped make the workflow easier for the team of freelancers. The model sizes were so large, and there were so many shots, Simpson says, that he had to construct a film production-like pipeline in which the animators could just call up a file and have it automatically load on their workstations. "They didn't have to worry about where to put the file and what to call it," he says. Additional code was scripted that automatically submitted each job to the studio's renderfarm each evening and redeposited the work into the users' work directories the next morning.

"We have heard about animators in America taking five months to complete a few shots for some feature-length films. We just did not have that luxury," says Simpson.

## Postcard Quality

While completing such a large project in such a short time frame was difficult, perhaps equally as challenging, Gordon notes, was recreating such a famous landscape without ever seeing it in person. "We had to create a warm, desert-like area that we've only experienced through films, and it had to be believable so viewers could instantly recognize it in the video," he says. "Many people think the footage is real and have asked how we got permission to make these shots and set off the explosions in the Grand Canyon."



Although the animators were shooting for photorealism, they also wanted to make the planes' movements appear less stringent and mechanical, which was accomplished using traditional keyframing techniques.

Not only did computer graphics add character to the piece, but it was far less costly than renting vintage planes and a helicopter to film actual landscape footage. Furthermore, using CG enabled the director to achieve what would have been impossible through traditional filming. For instance, by digitally creating the imagery, the director could fly the planes extremely close to the canyon walls, a stunt too dangerous for an actual pilot. In one stomach-turning shot, the planes barrel down a narrow gully between two stark walls, "something we could have never done in real life," says Simpson. "And it's one of the strongest shots in the video."

Indeed, the magic of computer graphics enabled Garbage's Shirley Manson to take to the sky in the video, but following the MTV Awards, it was the artists at Realise who were flying high.

**Key Tools** **RenderMan**, Pixar (www.pixar.com) infoNOW 56
**ShadeTree**, Cinema Graphics (www.cinegrfx.com) infoNOW 57

# REACHING FOR THE SKY

## Adding the missing spires to Notre Dame's bell towers

BY KATHERINE TYRKA

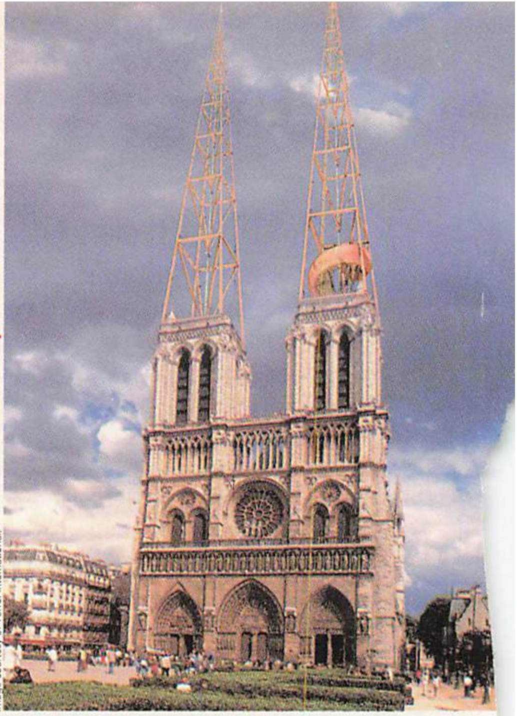
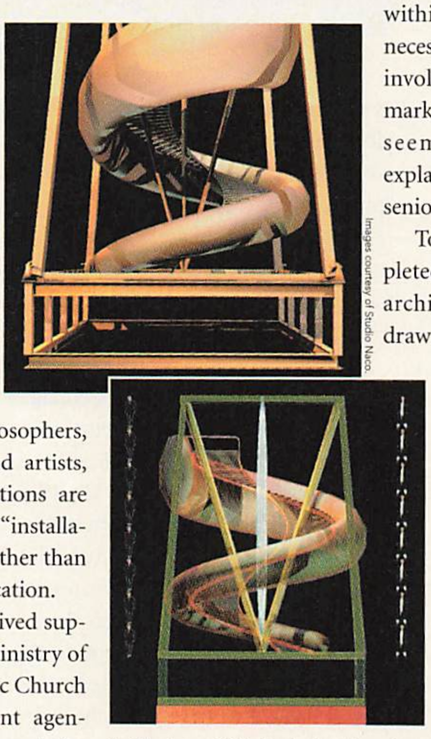


Image courtesy of Terrell International.

To help win public and political support for the Spires of Time project, Naco architects produced a 3D contextual model of the structure for use during presentations.

The Notre Dame cathedral has been a landmark in central Paris for the last seven centuries, despite that fact that its two rectangular bell towers—among the cathedral's most striking characteristics—have never been completed. Historians speculate that Notre Dame is missing spires, typically present in all Gothic churches, because the Catholic Church lost its influence over the French royalty and no longer possessed the political or financial influence to finish the 157-year building project. But now that may change—at least temporarily.

To herald the new millennium, Studio Naco, a Paris-based architectural firm, has designed a pair of temporary modern-style spires for the cathedral and has proposed their installation for the last three months of 2000 and the first three months of 2001.



Images courtesy of Studio Naco.

Architects used digital technology to perform structural analyses on the proposed spires, and to ensure that the spires could accommodate a spiral staircase.

Called the Spires of Time, the project to complete the Notre Dame towers is supported by an association comprising not only architects and engineers, but also philosophers, writers, economists, and artists, as the temporary additions are proposed more as an "installation" or "happening," rather than an architectural modification.

The project has received support from the French Ministry of Culture, but the Catholic Church and various government agencies have not yet approved the installation. To help win the necessary support, Naco modeled the spires in 3D to use as a visualization tool for presentations to government and church authorities. Meanwhile, the Paris office of Terrell International, an engineering firm, performed structural analyses to meet the requirements of the overseeing government boards.

## Monumental Changes

Because aesthetics played such an important role in this project, the group at Naco devoted its full attention to producing a complete contextual presentation model to accompany its 2D drawings. "The use of CG is particularly important, because with a building as well known as Notre Dame, it was crucial that we present the project not only in traditional 2D schema, but also fully within context. This is necessary for any project involving such a landmark, where modification seems unthinkable," explains Marcelo Joulia, senior architect at Naco.

To depict the completed building, the Naco architects used hand-drawn plans as a guideline for modeling the proposed spires in TGS International's (San Diego, CA) Amapi design software on a Macintosh G3 computer.

The 3D model further aided the architects in designing the asymmetrical spires (one includes a spiral staircase). "Even when we completed the initial 3D model, our design work continued," says Alain Renk, senior architect. "We modified the stairs to achieve a form that was more pleasing and better suited—something we otherwise may have not seen until we started construction."

## Critical Analyses

The digital imagery also enabled the architects at Terrell to perform a complete structural analysis to ensure that the historic building was capable of supporting the new design, whose light, pyramid structure projects a feeling of "virtual" spires reaching toward the sky.

To satisfy the various regulatory requirements and perform finite-element analysis on the design, Cyril Guilberteau created a more detailed 3D model of the spires from the hand-drawn plans using Staad-III (Research Engineer; Bristol, England). Using a Gateway 2000 PC, he modeled each spire bar, along with the cables and attachments, which formed an inverted pyramid within the four main support beams of an outer pyramid.

"Staad is well adapted for modeling and analyzing building-support structures, which are characteristics of the spires' design," says Guilberteau.

For the linear analysis, the engineer manually input the material constraints, provided by the suppliers, into the system. However, more detailed analysis was re-

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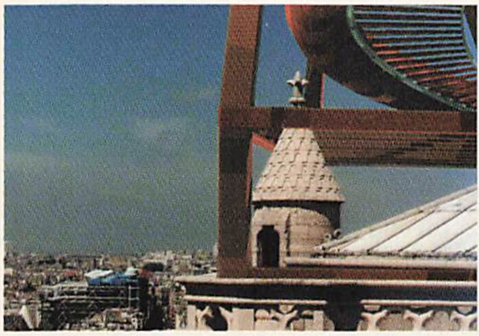

Image courtesy of Studio Naco.

Although the proposed additions have been well received by some, the Catholic Church has yet to grant its approval.

quired by two regulatory bodies. SOCOTEC (the French Office of Technical Verification) required analysis of the increased pressure exerted on the church towers caused by violent winds, while the French Scientific and Technical Building Center focused on the structural stability of the spires themselves to endure torsion (twisting) effects during violent crosswinds.

"The various analyses dealing with the effect of wind on the spires was the most difficult," says Guilberteau. "The [inverted pyramid] design of the spires is unusual, so we were required to analyze the worst-case scenario, meaning winds at 200 kph (125 mph), whereas the strongest recorded wind in Paris was 167 kph (104 mph) in 1967. We also couldn't use standard calculation formulas, because the behavior of the skeletal design of the spires would be different from more traditional structures."

Although difficult to calculate, the wind and torsion analyses proved to be quite valuable. As a result of the work, a cable spiraling from the top to the bottom of the spires was added to the design to anchor the inverted pyramids and better protect the structure from any twisting due to violent winds.

Even the proposed installation of the spires is atypical because they must be installed and removed without damage to the church. To show the delicate assembly process—a crane would place the first section of each spire, while the remaining three sections would be installed by a helicopter—the London office of Terrell International produced a simulation using Autodesk's (San Rafael, CA) 3D StudioViz.

According to Joulia, the millennium project originated with the idea of modifying people's perception of a monument with a temporary installation, to make it fresh to the public eye for the new millennium. Notre Dame was a perfect choice, he says, because it is an international monument with both sacred and secular importance. "The possibility of reinvigorating both the church and the square in front of the church by erecting these spires would bring a new level of community to this site," he adds.

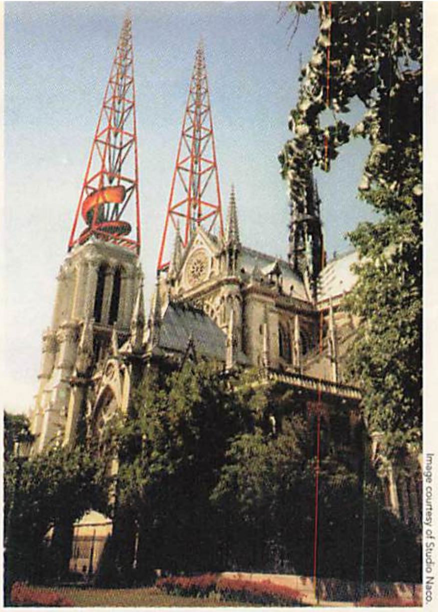

Image courtesy of Studio Naco.

To make the visualization more realistic, the designers used Photoshop to incorporate the CG spires into compelling photographs and postcards of the church.

*Katherine Tyrka is a freelance writer based at the GEID Press Agency in Paris. She can be reached at ktyrka@compuserve.com.*

**Key Tool** **Staad-III**, Research Engineer (www.reiusa.com) infoNOW 58

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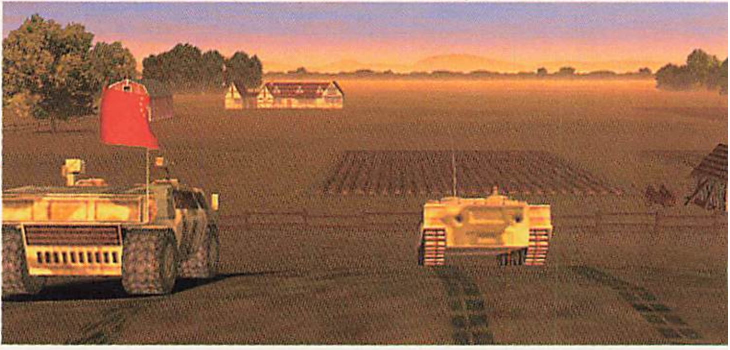
GAMING

# WAR GAMES

## Controlling an army of detailed 3D objects

BY KAREN MOLTENBREY



Images ©1999 Red Storm Entertainment.

To create the game's terrain, the artists used actual geographical data for reference, then modeled it in 3D, exaggerating some features to make the area look more dramatic.

It's no small feat to maintain command of an entire platoon of army vehicles in the throes of battle. But that was precisely the degree of control game developers at Red Storm Entertainment (Research Triangle Park, NC) wanted to give players of its new real-time, all-3D tactical war game for the PC, *Force 21*. "Until now, computer technology wasn't powerful enough to make polygon-intensive games such as *Force 21* feasible," says Mike Cosner, lead artist at Red Storm. "But our engineers did an impressive job designing a game engine capable of handling our demanding 3D needs."

Like the game engine itself, the *Force 21* players must also be combat ready as they control the vast array of military vehicles under their command as head of the Chinese or joint US/Russian forces. "The benefit of *Force 21* is that you have the opportunity to engage in combat from two different points of view," notes Cosner. "Not only does your outlook on the game change, depending on which side you choose, but so do your tactics, since both sides have different strengths and weaknesses associated with their vehicles."

*Force 21* is set in the year 2015, a time of economic prosperity for China and social chaos for the former Soviet Union. Seizing an opportunity to acquire natural resources to fuel its growth, China pushes into neighboring Kazakhstan, a former Russian republic

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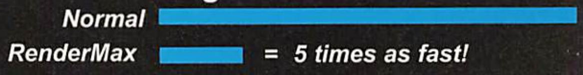

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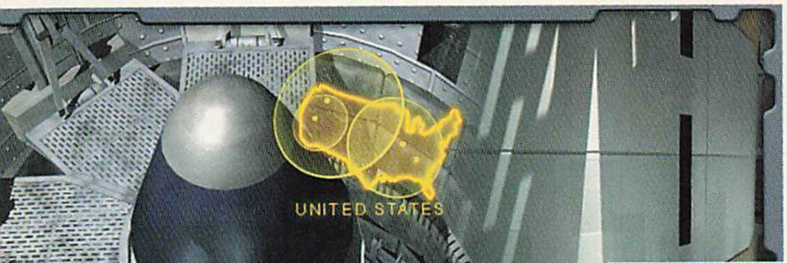
*Force 21* can be classified differently than most computer games; instead of controlling characters that are up close to the action, in *Force 21,* players control a multitude of military vehicles from a viewpoint they choose, either above or behind the action. This adds to the geometric and intelligence complexity within the game scenes. "The game is a true 3D combat game, where players traverse rivers, set up fortifications, call in air strikes—all the capabilities essential in war," Cosner says.



**Developers spent a great deal of time refining 3D algorithms so the new game engine could process the extensive amount of geometry used in the all-3D *Force 21* release.**

## Taking Command

*Force 21* is packed with realistic military models, enabling the player to control up to 48 vehicles at a time. To achieve the desired realism, Cosner and the other development team members visited the National Training Center at Fort Irwin, California, for a firsthand look at military vehicles in mock-warfare training simulations. The developers also received military aid from producer John Farnsworth, a captain in the US Army, who assisted the group in obtaining much-needed resource material.

To model the objects—from tanks to helicopters—the artists used Discreet's (Montreal) 3D Studio Max running on Windows NT workstations, while texturing was done with Adobe Systems' (San Jose, CA) Photoshop. To create the snowfall, explosions, and other special effects, the team used a proprietary particle system borrowed from some of the company's previous games.

Included in the game is a mission editor, which lets users take *Force 21* a step further and create their own missions. By importing a gray-scale height map, which the engine uses to interpret terrain data, players can populate the landscape with 3D objects from the game's library to constantly devise new scenarios.

A new game engine—the third thus far for Red Storm—was created not only for game play and object intelligence, but also to handle the large amount of geometry, as just about everything in the game, from the vehicles to the terrain, is polygon-based. Typically, 3D game objects range in size from 300 to 500 polygons, "so when you multiply that by 48 [the total number of vehicles that can be commanded], you're pushing a lot of polygons," Cosner says. "The best feature of the game engine is that it enables you to have so many 3D vehicles under your control at any given time. This lets you amass a large force and confront another opposing force, then see this large-scale battle take place right in front of you."

To achieve this high level of control, the engineers spent a great deal of time researching existing game engines that enabled the extensive 3D play the group envisioned for *Force 21*. What they found "didn't make the grade," Cosner says. "They all had 3D environments but the objects controlled by the player were 2D. We wanted an all-3D game."

This required the engineers to refine 3D algorithms to handle all the mathematics associated with the additional geometry, which resulted in faster and more efficient processing. Also, with the release of 3D PC accelerator cards, the group was able to create even more immersive 3D game environments by offloading some of the geometric processing chores from the game engine to the player's computer.

To produce the game's grandiose scale required the developers to conquer a few technical challenges of their own, a coup involving just four artists. "The most difficult aspect was creating a game on such a large scale using so much 3D geometry," Cosner says. Initially, the modelers set the highest level of detail for the vehicles at about 500 polygons, but early tests proved this to be unrealistic, so they had to be brought down in size to about 350.

One of the last major missions before completing the modeling and animation was making sure the 3D game played well and the vehicles, effects, and environments looked good on lower-end systems (at minimum, a 233MHz Pentium MMX).

"We created an enormous amount of content for this game, but the graphics quality never suffered," Cosner notes. "In a lot of games, you'll typically find areas with great graphics and other areas where they fall short. But in *Force 21*, high-level graphics are found globally in the game."

**Key Tool** **3D Studio Max**, Discreet (www.discreet.com)
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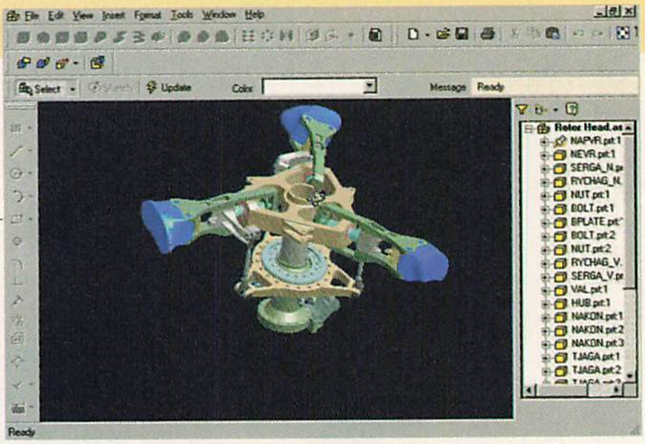

**Autodesk's Inventor allows users to work in very large assemblies, such as this helicopter rotary system.**

# Autodesk's Inventor

## Adaptive design technology highlights new MCAD release

BY EVAN YARES

Three years ago, Autodesk decided to write the next-generation CAD program—one so powerful and well designed that it could ultimately win the business of the most demanding users: companies that make airplanes and automobiles. Though Autodesk hasn't actually stated that this was its goal when it set out to develop Inventor, a careful look at the new Autodesk mechanical CAD program (previously code-named Rubicon), seems to confirm that intent.

On the surface, Inventor's specifications are similar to those of its major competitors: Solid Works, Solid Edge, and Pro/Engineer. It runs on Windows NT, creates feature-based solid models, assemblies, and associative drawings, uses the ACIS modeling kernel from Spatial Technology, and sells for $4995. But looking past the surface, you find a program that, despite its first-release limitations, is destined to be a major player in the mechanical CAD market.

The factors that define a great CAD program are fairly simple. It must be easy to learn and use, so that the average person can become productive with little formal training. It must be powerful enough to do whatever a user wants it to. And it must be inexpensive enough that any company can afford to put it on the desk of every person who can benefit from it.

Consider ease of use. Until a few years ago, all the effort was spent on making CAD programs work in the first place, and ease of use was an afterthought. With Inventor, ease of use is a primary consideration. The program has an exceptionally well thought-out interface, offering such features as a high-inference sketcher and gesture-based interactivity.

In the realm of power, Inventor is a mixed bag, if only because it is still in its first release. One of its strengths is that it was designed from the ground up to handle very large assemblies. In one example provided by Autodesk, Inventor was able to load an assembly with 3100 components (of which 320 were unique) in 39 seconds on a 500MHz computer. I noticed, however, that the assembly provided (a manufacturing cell) included mostly simple parts, with few curved surfaces. So I created an assembly of 300 unique parts, each of which included complicated NURBS surfaces. On my 333MHz computer, it loaded in 73 seconds. And I was able to effectively edit any of the parts in the context of the assembly without undue delay.

Another strong area for Inventor is assembly editability. Most CAD systems create an ordered dependency between mated parts in an assembly. That is, if you change Part A, Part B will reflect the change, but you can't change Part B and have Part A follow suit. Inventor, however, incorporates a unique technology, called Adaptive Assembly Modeling, which allows just this type of flexible assembly editing. To utilize Adaptive Assembly Modeling, the user selects which part features may change when a mating part changes.

### Inventor

**PRICE:** $4995

**MINIMUM SYSTEM REQUIREMENTS:** Windows 98/NT; 300MHz Pentium CPU; 512MB of RAM; 100MB hard-disk space; fast SCSI disk subsystem; OpenGL graphics adapter; 4MB of video RAM

**Autodesk**

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The areas of weakness in Inventor are mostly missing features. Among the notable ones are advanced surface design, advanced lofting, exploded drawing views, and IGES translation.

The discipline for which Inventor is best suited is clearly industrial machinery design. The combination of large-assembly capabilities with adaptive assembly design makes Inventor a dream for this—and it is, in my opinion, a better choice in this area than any of its competitors. (One of those competitors is Autodesk's own Mechanical Desktop program, which, though lacking Inventor's adaptive technology, does handle integrated surface modeling. According to Autodesk, however, Inventor and Desktop are aimed at separate markets—advanced 3D MCAD design, and integrated 2D and 3D design respectively.)

Among those areas for which Inventor is not yet suited are sheet metal design, injection mold design, and any consumer product design requiring cosmetic surfaces. Inventor is not inherently limited in these areas; it's simply that the specific tools necessary to address these disciplines aren't present in this release of the software.

Autodesk has put three years of work into Inventor so far, and that time has included a lot of planning and foundation work. If Autodesk has planned successfully, it will ultimately be able to compete in the top tier of the CAD market and win the business of some of the most demanding customers. If it stumbles at all, it will be relegated to the mid-range market—which, although substantial, is also populated with strong competitors. One thing is clear, however: Autodesk is serious about the mechanical CAD market.

*Evan Yares is a consultant, speaker, and writer in the field of engineering software. He is also president of the CAD Society.*

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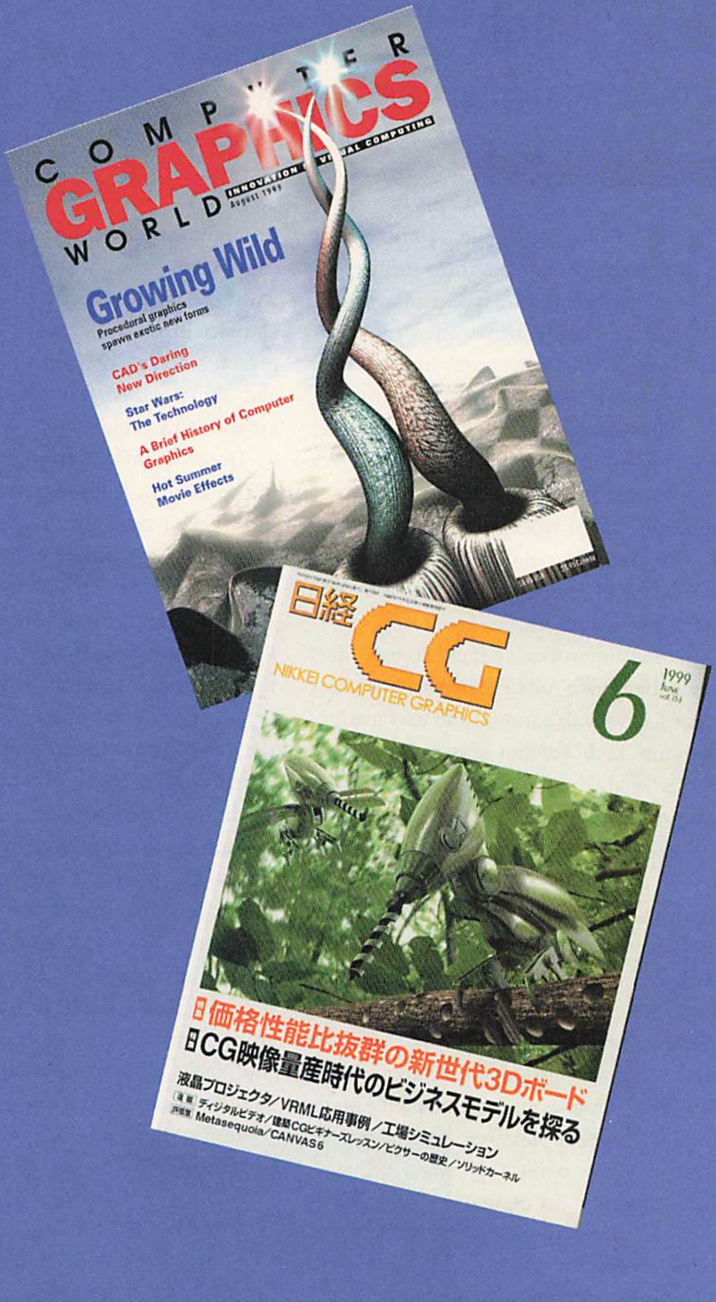
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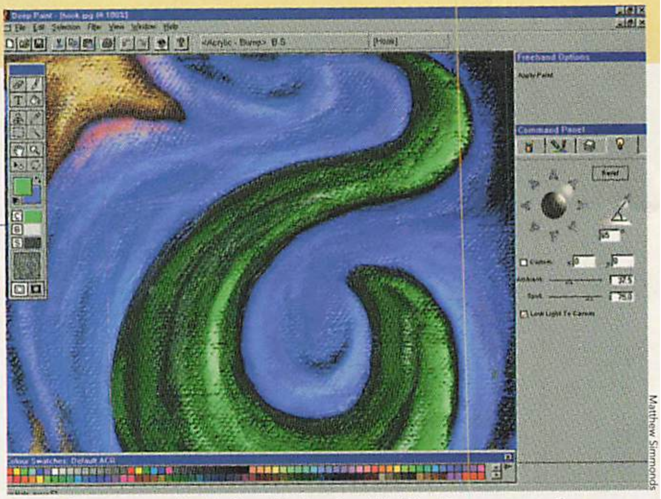
# Nikkei Computer Graphics

# Deep Paint

## A realistic digital paint program

BY DOUG KING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Matthew Simmonds

**Deep Paint users can adjust both ambient and spot lighting. Because properties such as bump, shine, and texture are intrinsic to the paint and canvas, users can change the light at will to see how it affects their finished work.**

Deep Paint, available from Right Hemisphere, is an advanced paint application offering a realistic painting experience for digital artists. The term "deep" comes from the program's unique ability to provide users with full artistic control over the shininess and depth of paint, whether working in oils, acrylics, watercolors, or chalks. And Deep Paint has other features—numerous media types and textures, lighting controls, and a procedural Image Spray tool—that make it a remarkably different and incredibly useful package.

Deep Paint works as a standalone product or as a plug-in to Adobe Systems' Photoshop. It is effective with a mouse and uses many of the same keyboard hot keys as Photoshop, but is really impressive when used with Wacom's Intuos tablet, and especially with the tablet's new airbrush stylus.

Deep Paint's interface is similar to Photoshop's. The software provides all the tools you'd expect in a professional paint package, including masking, color picker, fill, text, eraser, image processing, standard cloning, and cut-and-paste floaters. But what sets it apart from other paint packages, including Photoshop, is its incredible attention to media texture. Almost every paint type has texture, or depth, and each of the software's 21 canvas types can also have a unique texture that affects the look of the paint and the way it spreads. If you're painting with the acrylic paint on a rough canvas, for instance, the paint covers only the high areas of the canvas. What's more, by adjusting the canvas texture, you can set how much the canvas will affect each paint medium. In addition, the product's paints automatically come with depth information, and each brush stroke has a preset amount of bump and shine. These features are user-adjustable.

**Deep Paint**

**PRICE:** $249

**MINIMUM SYSTEM REQUIREMENTS:** Windows 95/98/NT with Internet Explorer 3.02 or better; 200MHz Pentium or compatible CPU; 64MB of RAM; 20MB of hard-disk space; 800x600x16-bit graphics. Highly recommended: 1024x768 True Color graphics or higher and Wacom or similar pressure-sensitive tablet

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Deep Paint's lighting controls are impressive. In addition to adjusting the direction of the light source, you can also manipulate the amount of ambient light versus spotlight. This is a feature worth experimenting with. By dropping the spotlight amount to zero and setting ambient light to a high level, for instance, you can get a strikingly flat image. Adjust the lights the opposite way and you have brilliant, dimensional artwork of which Rembrandt might have been proud.

Another outstanding feature is the 53 media the program offers, including oil, pastel, crayon, charcoal, and felt tip, plus an additional 39 variations of those. In addition to all these standard paint types, you get a huge assortment of textures, ranging from common, such as wood, bark, metal, and snake skin, to unusual, such as alien wire and slime. You can select from 117 procedural image types to create amazing textures for 3D models, enhance your photo manipulations, or create awesome-looking new art. The number of media types alone makes this a unique and great package.

Also remarkable is the way in which you can manipulate the software's brushes and paints. One simple tutorial in the manual has you "dab" blobs of paint onto the canvas in each of the primary and secondary colors. At once you notice how the colors interact and blend as you mix them. The tutorial then instructs you to use the Smudge tool (you can choose from Smudge, Smudge Finger, and Smudge Stick) and "pull" the colors across one another. As the colors blend and mix, they still retain the rounded, shiny look you would expect from a thick blob of paint.

The software's Image Spray tool, which enables you to paint with photographs, is also outstanding. Essentially, you drag a brush over the canvas, and a photographic image appears that follows the parameters of the brush you are using. You can blend different image sprays to create incredible looks and effects. For instance, maybe you need an image of a stucco wall with brick showing through. Spray an image of brick, then spray an image of stucco over certain areas, blend the two, add drop shadows, and you have what looks like a photograph of a stucco and brick wall. Because the Image Spray tool is procedural, you can use any image type you select to create seamless, tileable textures for use in any 3D program. For this reason alone, Deep Paint is worth having.

Deep Paint is a program without comparison. I enjoyed using it and was comfortable with it within seconds of firing it up. The vast number of paints and effects the software offers make this tool a must-have for digital artists.

*Doug King is a Computer Graphics World contributing editor. He can be reached at drk@airmail.net.*

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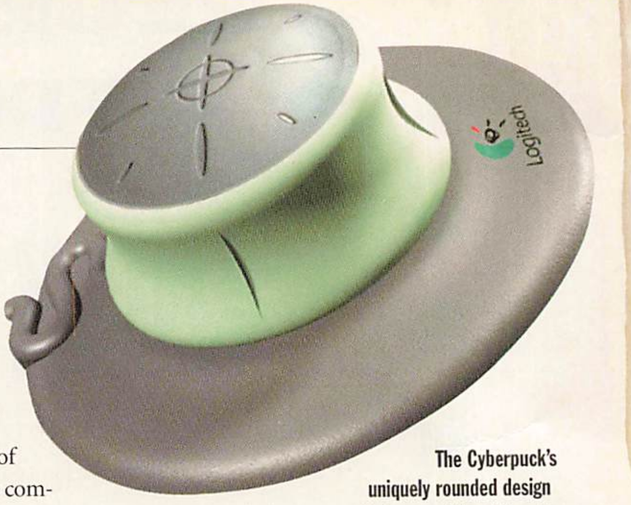
# Cyberpuck

## LogiCad3D's entry-level motion controller

BY JOE GRECO



**The Cyberpuck's uniquely rounded design features a cap that users tilt and turn to navigate in six degrees of freedom, plus "buttons" on the surface of the cap that can be programmed to provide custom functions.**

Ever since 3D programs first appeared over 25 years ago, the question of how to navigate in 3D space while interacting with a 2D screen has been a thorny one. Many solutions, including General Reality's DataGlove and various stereoscopic displays, have emerged over the years. One of the leaders in addressing this problem has been Logitech, which makes 3D motion controllers that behave somewhat like a combination of mouse, trackball, and joystick. The latest addition to this family of products is the Cyberpuck, with its uniquely rounded, elegantly simple shape.

The Cyberpuck had its beginnings in the early 1990s, when Logitech formed an agreement with the European company SpaceControl to market its 3D motion controller, the Space Mouse, in the US under the name Magellan. The latest incarnation of this product is the Magellan Plus (above), which features a shape sculpted to support the user's wrist and a generous allotment of buttons, which are used for speedy access to a variety of application specific commands.

**With its ergonomic styling and 11 programmable keys, LogiCad3D's Magellan Plus represents the high end of the company's 3D motion controller line.**

Last year, Logitech spun off LogiCad3D to handle its motion-controller product line, and the Cyberpuck is the first offering from the new company. The Cyberpuck features a unique design at a price of $395—considerably less than the company's Magellan offerings, and less than similar products such as Labtec's SpaceBall.

Underneath its cap, the Cyberpuck consists of the same opto-electric and contactless measuring system on which the higher-priced Magellans are built. But the Cyberpuck's simple, rounded form, coupled with the absence of raised buttons, has resulted in a device that is less expensive to manufacture. Because it is aimed at the entry-level market, it works only with Windows and has no support for Unix or Linux.

The idea behind the Cyberpuck, or any motion controller, is essentially the same—to allow users to pan, zoom, and rotate a 3D model on-screen, with six degrees of freedom. Resting on top of the internal measuring system is a cap that provides the navigational control—as it is tilted toward one direction, the model on the screen tilts in the same direction. The best way to think of the cap is to visualize it as the model itself, which instead of being on the computer screen, is now resting at your fingertips.

In lieu of raised buttons, the Cyberpuck does have five "virtual buttons" that can be programmed. These respond to fingertip pressure in areas marked on top of the device, allowing users to invoke functions just as with their physical counterparts on LogiCad3D's other 3D motion controllers. I found accessing these virtual buttons easier than accessing the raised variety on the Magellan series because they are nearer your fingertips—there is no need to stretch over the device's cap to hunt for them.

**Cyberpuck**

**PRICE:** $395
**OS:** Windows 95/98/NT
(Magellan Plus is $745 and runs on Unix and Windows 95/98/NT)

**LogiCad3D, A Logitech company**

Fremont, CA
510-659-8000
www.logicad3d.com

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According to LogiCad3D, over 70 CAD and 3D applications are supported by the Cyberpuck. Most of the programs I tested with the controller worked the first time around, including Mechanical Desktop, SolidWorks, and 3D Studio Viz. With every application, the "feel" of the device was the same (the cap operated in a consistent manner). This is a plus for users who frequently employ several 3D applications per day.

Besides traditional CAD and 3D applications, the Cyberpuck also works with 3D Web packages such as VisScape from SuperScape. Programs like these are basically 3D browser plug-ins that allow for virtual worlds to be displayed and interacted with on the Web.

The Cyberpuck is easy to install via a 9-pin serial connector. Unlike similar products I have used, there are no adapters included—an inconvenience should your computer have only a 25-pin serial port.

For almost anyone involved in 3D, whether for engineering or virtual Web navigation, LogiCad 3D offers a simple, affordable solution. The Cyberpuck's price point makes it very attractive, especially to those getting started in 3D.

*Joe Greco is a writer and trainer specializing in CAD and 3D products.*

# The Story of Computer Graphics

## MEMO FROM THE PRODUCERS

***The Story of Computer Graphics*** **premiered on August 8, 1999 at SIGGRAPH 99, Los Angeles, CA**

**LENGTH: 93 MINUTES FORMAT: HDCAM, OR D5 PLAYBACK**

**We had a large audience at the Shrine Auditorium premier (about 3,000) and each of the 25 subsequent showings at the LACC drew almost full-houses (about 300 people)....for a total of roughly 10,000 viewers during SIGGRAPH 99.**

**We're starting to formulate distribution plans which include possible TV (PBS) showings and several film festivals. These include Eurographics 99 in September, (Milan), DIGIFORM in October, (Belgium), and the Museum of Science in November, (NYC). We expect to sell copies of the tape by mid-2000...and we're developing a plan for distribution to our sponsors, interviewees, committee folks and others. Check this site (http:/www.siggraph.org/movie) for the latest info about the film's availability.**

**This project could not have been completed without the enormous help and support from ACM SIGGRAPH and SIGGRAPH volunteers, our other sponsors, our interviewees, our image and clip suppliers, our SIGGRAPH contractors and the professionals and volunteers who produced, wrote, shot, and edited the film.**

**THANK YOU ALL...AND WATCH FOR THE NEXT SHOWING!!**

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— *Variety*

"...a flood of dazzling color and imagery..."

— *Los Angeles Times*

LOOK

"...(one) segment alone could serve as a five-minute graphics primer for every school in the country ... many of the graphics are just eye-popping when on the big screen."

— *L.A. Daily News*

"*The Story of Computer Graphics* certainly delivers the goods."

— *The Hollywood Reporter*

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**FRANK FOSTER**
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**JUDSON ROSEBUSH**
WRITER

**ROBERT CARR, TONY FORESTA, ANDREW SOBKOVICH**
DIRECTORS OF PHOTOGRAPHY

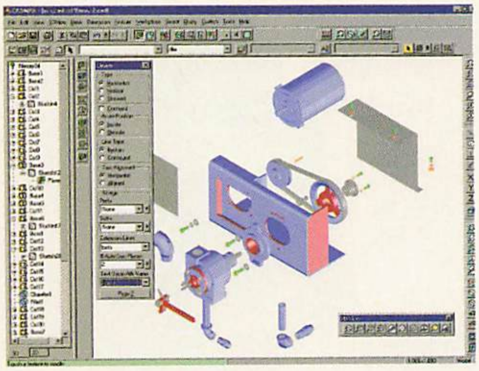
Original Concept: Walt Bransford
Hi-Def Post Production: Robert Hopkins, SONY PICTURES HIGH DEFINITION CENTER
Hi-Def VFX Supervisor: Steven Robiner
HD On-Line Editor: Jim Ward
HD Engineering: Rafael Adame, Dale Hunter
Digital Post Production Audio Services Provided By Sony Pictures Studios Post Production Sound

## SOFTWARE

### DESIGN ENGINEERING

#### SOLID MODELER

**WIN** CADMAX Corp.'s Solid Master mid-range solid modeling program for mechanical CAD provides modeling alternatives such as parametric, feature-based solid modeling, Boolean solid modeling, free-form surface modeling, and 2D drafting. In feature-based solid modeling, the software provides the ability for engineers to simultaneously model multiple parts and mix models, production drawings, and assemblies in a single file. The product is sold over the Internet for $1995. (Baltimore, MD; 410-532-2803; www.cadmax.com)



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#### PRODUCT DESIGN/MANUFACTURING

**WIN** A key enhancement to I-DEAS Artisan Series, Release 4, from SDRC is the addition of collaboration capabilities, which build on the company's I-DEAS Team Data Manager software. Data can be shared associatively and bi-directionally between I-DEAS Artisan Series and I-DEAS Master Series. A new toolpath engine is significantly faster for surface-finishing operations and provides greater control over toolpath creation. Extended capabilities in automated flanging enable complex 3D associations to be developed between industrial design, or styled class 1 surfaces, and the supporting structural geometry. VGX Moldbase automates the design of fully assembled molds starting with standard moldbases and components. (Milford, OH; 513-576-2400; www.sdrc.com)

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#### ARCHITECTURAL ENGINEERING

**WIN/MAC** The cross-platform version of DenebaCAD from Deneba Software is available for Windows 95/98, NT as well as Mac OS computers. The software integrates precision 2D drafting, interactive 3D modeling, and fast photorealistic rendering into a single application. This version offers enhanced performance and DXF and DWG r14.01 I/O support with complete and accurate translation of all 2D-, 3D-, and text-object data during any file import and/or export operation, as well as AutoCAD-style external referencing. The price is $499.95. (Miami, FL; 305-596-5644; www.deneba.com)

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### MODELING & ANIMATION

#### PRODUCTIVITY PACK

**WIN/MAC** Intended for 3D artists and designers, the MetaCreations 3D Suite includes Bryce 4, Canoma, and Poser 4 for creating 3D worlds, landscapes, architectural walk-throughs, and posed or animated humans and animals. The ability to export the MetaStream format from each application ensures the quick creation of streaming, scalable, Web-based 3D content for Internet graphics. The price is $599. (Carpinteria, CA; 800-846-0111; www.metacreations.com/products/3dsuite)

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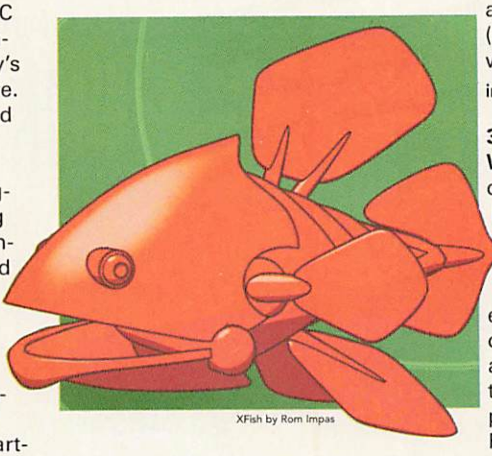
#### TOONS AND ILLUSTRATIONS

**WIN** New from Digimation is Illustrate! 4.0, a cartoon and technical illustration renderer for 3D Studio Max. The Rendering Wizard sets up the animator's output simply and easily. The user answers a series of questions, including output format, background color, and so on; then the software prepares the rendering. The price is $395. (St. Rose, LA; 504-468-7898; www.digimation.com)



XFish by Rom Impas

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#### IMPROVED RENDERING

**WIN** Softimage 3D version 3.8 SP2 from Avid Technology includes mental ray 2.1 rendering software, which offers improved image quality and faster previewing and rendering. Global Illumination produces natural-looking reflected light, enabling users to create more realistic images with fewer light sources and easier setup. Caustic Effects recreate the reflected or refracted light as projected through water or crystal. Other features include shadow mapping and polygon displacement mapping. Automatic, incremental object re-tessellation, grid acceleration, and selective feature disabling improve rendering performance. The service pack is free. (Montreal, Quebec; 514-840-0299; www.softimage.com)

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#### OCEAN DESIGNS

**WIN/MAC** Atomic Power's Psunami 1.0 generates the precise 3D geometry of an ocean surface, then produces ultra-realistic raytraced output using the RenderWorld render engine. Artists can design, animate, and render 3D oceanographic effects within Adobe After Effects 4.0. Features include a grayscale mode for setup and output as a displacement map, depth-of-field rendering for incorporating additional layers into an ocean comp, the ability to attach a camera to the waves' surface for a realistic bobbing motion, and displacement mapping for custom water behavior and stylistic effects. The price is $599. (Encinitas, CA; 760-516-9000; www.AtomicPower.com)

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#### 3D PLUG-INS

**WIN** BlackFeet Company offers V2.0 of Dei Tools. Products include Defocus Dei, which enables users to simulate the effects of depth of field on computer-generated images; Polygon Cruncher, which enables users to reduce the number of points and faces on 3D models; and 3D Browser, which enables users to create catalogs of 3D objects. The products cost $69 each. (Bordeaux, France; www.blackfeet.com)

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### MULTIMEDIA/VIDEO

#### EDITING UPGRADE

**UNIX** The version 7.5 hardware and software release for Editbox from Quantel improves the all-round productivity and functionality of the system and enhances the ability to share between the company's editing product range. History editing helps keep work uncommitted, enabling creative experimentation and improving the compositing workflow. Via the external Quantel Open Render Engine, users have access to 5D's Monster effects plug-ins as well as other third-party plug-ins. The Java package includes the Java Virtual Machine, which enables third-party programmers to write native Java applications for Quantel systems. Global channel control and ganging are new keyframe management features that facilitate the job of carrying out complex multichannel moves. The software part of the package is offered as a free upgrade to Editbox Version 6 owners. (Darien, CT; 203-656-3100; www.quantel.com)

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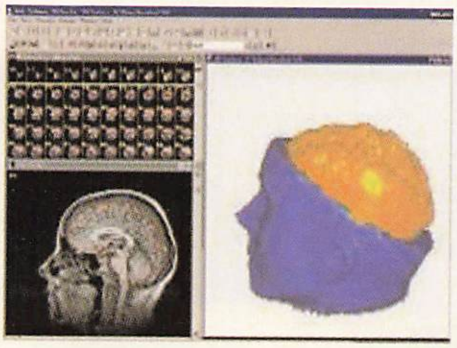
## VISUALIZATION

#### IMAGE DOCTOR

**WIN** 3D-Doctor 2.1 from Able Software includes 3D image segmentation, 3D surface and volume rendering, deconvolution, image measurement, 3D registration, and fusion functions for microscopy imaging and medical imaging applications. Users can define multiple regions of interest for both fully automatic and interactive 3D segmentation to extract object boundaries. These can be modified and manipulated using the vector-based editing tools. 3D surface model and volume rendering are then created from the object boundaries for visualization and analysis. The 3D model data can be exported to AutoCAD DXF, 3D Studio, VRML, and other 3D formats. The price is not available. (Lexington, MA; 781-862-2804; www.ablesw.com)



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## WEB DESIGN

#### WEB SPEAK

**WIN/MAC/UNIX** Cult3D 4.0 from Cycore is a sound-enhanced version of the company's animation technology for the Web, which enables interactive 3D objects to speak to users. Voice compression technology makes it possible to include voice-overs, product explanations, and recorded training instructions with any object posted on the Web. The new Cult3D Exporter enables users to export 3D models from 3D Studio Max. Other new features include multiple event-screen viewing, drag and drop between event maps and dialog controls, stereoscopic object viewing, and hierarchical view of exported scenes. The Cult3D development tool and plug-in are available free for download at the company's Web site. A licensing fee of $3600 is charged for objects once they are posted to a commercial Web site or Web store. (San Mateo, CA; +46 18 65 65 60; www.cycore.com)

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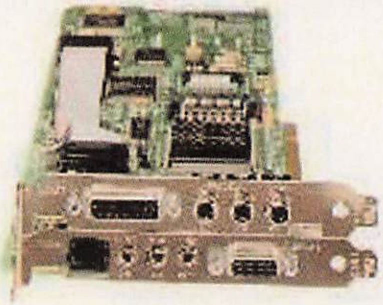
# HARDWARE

## BOARDS

#### INTERNET VIDEO

**WIN** With an advanced on-board processor and patented operation system, the i.c. LIVE card from MAX Internet Communications accelerates Internet video and can enable a basic computer to send and receive full-screen, full-motion video communications over the Internet or LAN. Other capabilities include MPEG-1 and DVD play capabilities with output to monitor or NTSC-TV, and AC3 surround sound audio. The price is not available. (Dallas, TX; 800-479-7146; www.maxic.com)



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#### HIGH-END OXYGEN

**WIN** By combining two GLINT R3 rasterization engines with the 5000Mflop GLINT Gamma G2 geometry processor on a single-slot AGP card, the Oxygen GVX210 from 3Dlabs delivers balanced high-end performance for OpenGL and Direct3D applications. The product features a 256-bit memory bus, 64MB of on-board memory, and 256MB of virtual textures. It delivers a fill-rate of 460M dual bilinear mip-mapped texels/second and more than 6.3M lit, transformed polygons/second geometry throughput. The price is $1999. (Sunnyvale, CA; 408-530-4750; www.3dlabs.com)

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## INPUT/OUTPUT

#### FLATBED SCANNERS

**WIN** From Hewlett-Packard come four color flatbed scanners: HP ScanJet 3300C and HP ScanJet 6300C, 6350C, and 6390C Professional Series. All incorporate HP Intelligent Scanning Technology, which provides excellent image quality, increased task productivity, and ease of use. The Professional Series scanners optimize scanned images and text for the Internet. The software bundle includes HP Precision Scan Pro 2.0, HP PrecisionScan LAN, HP ScanJet Copy Utility, integrated OCR, Caere Pagekeeper Standard 3.0, Adobe PhotoDeluxe Business Edition 1.1, and Boomerang WebShop 5.0 e-commerce and Web site creator software. The price ranges from $149 for the 3300C to $899 for the 6390C. (Palo Alto, CA; 800-722-6538; www.hp.com)

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#### DIGITIZER

**WIN** Create 2D or 3D models by "touch-tracing" the surface features of actual physical objects using theTechno 3-D digitizer from Techno-Isel. 3D models are constructed using points, lines, polygons, splines, or NURBS. The data can be exported in DXF, OBJ, TXT, IGES, and other formats. The points collected from the touch-tracing procedure can be entered directly into Mastercam Rhino 3-D, AutoCAD, SurfCam, and other design software. The unit's work envelope is a 50-inch sphere with an accuracy of 0.009 inch. The sampling rate is up to 1000 points/second. The price is not available. (New Hyde Park, NY; 800-948-3246; www.techno-isel.com)

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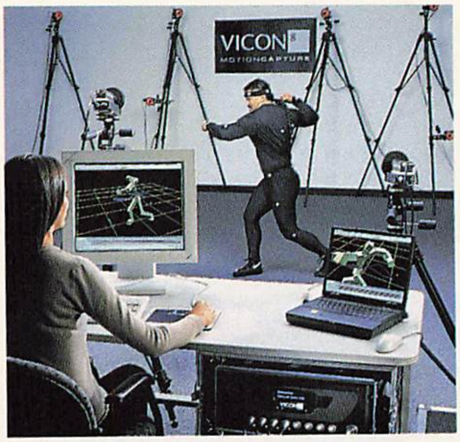
### MOTION CAPTURE

**WIN** New from Vicon, the Vicon8Rt produces full-body motion-capture data and renders live characters in animation packages such as Avid's Softimage, Discreet's 3D Studio Max, Alias|Wavefront's Maya, and Kaydara's FilmBox. The system recognizes a human or animal when it walks into the capture space, and starts tracking. Even when markers are obscured from view, the system continues to track until the last body segment is lost, then re-initializes on the fly. It delivers accurate 3D marker tracks and model degrees-of-freedom in real time, recorded by a 3D animation application or by the integrated recorder. The character motion can be used to drive 3D animations on any suitable TCP/IP-networked workstation. (Tustin, CA; 714-259-1232; www.vicon.com)



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### 3D PRINTER

**WIN** Using the Z402 3D printer from Z Corp., engineers and designers can create physical concept models from three-dimensional CAD data at a rate of between one and two vertical inches (25 to 51mm) per hour. Most handheld parts can be printed in less than one hour. Because parts created on this system are porous, they can be infiltrated with a variety of substances to give them strength and other characteristics such as temperature or water resistance. The heart of the system is a standard 128-jet ink-jet printer. (Somerville, MA; 617-628-2781; www.zcorp.com)

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### NEW INTERFACES

**WIN/MAC/UNIX** Fakespace Systems offers three new user interface devices for use with large-scale visualization display systems. The $5000 NeoWand is for use in spatially immersive environments such as the Immersive WorkRoom and CAVE. It combines the functionality of a VR wand or stylus with the familiar interface of a handheld remote control. The $10,500 NavPod is a pedestal or desk-mounted navigation device for use with large-scale wall or room displays such as the Immersive WorkWall. The user grips each end of a 12-inch-long horizontal bar and pushes or turns gently in the direction he or she wishes to drive the perspective for viewing. The third device, the Cubic Mouse, which is expected to be available by the end of the year, is a handheld, cube-shaped device that enables users to manipulate huge sets of 3D data. Turning the cube in space changes the position of the volumetric data being viewed, and a click of a button freezes the position. (Kitchener, Ontario; 519-744-7111; www.fakespace.com)

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## EVENTS

### NOVEMBER

**15-19 · Comdex/Fall '99,** held in Las Vegas. Contact: ZD Events (781-433-1805); www.comdex.com

**16-18 · Digital Media World,** held in London, UK. Contact: Advanstar Communication (+44-1244-399-180); (fax: +44-171-559-9779); www.digmedia.com

**16-20 · The International Association of Amusement Parks and Attractions (IAAPA),** held in Atlanta, GA. Contact: IAAPA (703-836-4800); (fax: 703-836-2824); www.iaapa.org

### DECEMBER

**1-4 · EuroMold '99,** held in Frankfurt, Germany. Contact: DEMAT Expo Management (tel: +49-69-23-43-31): (fax: +49-69-25-30-71); www.euromold.com

**12-13 · Game Developers RoadTrips Conference,** held in Boston. Contact: GDC RoadTrips (415-905-2388); (fax: 415-905-2222); www.gdconf.com/rtdm.

### JANUARY

**4-8 · MacWorld Expo,** held in San Francisco. Contact: IDG Expo (781-551-9800); (fax: 781-440-0300); www.macworldexpo.com

**17-20 · Medical Design & Manufacturing (MD&M) West 2000 Conference and Expo/Pacific Design Engineering Show/Medical Packaging Symposium,** held in Anaheim, CA. Contact: Canon Communications LLC (310-445-4200); (fax: 310-996-9499); www.pacdesignshow.com

**24-26 · DaratechPlant 2000,** held in Houston, TX. Contact: Daratech Inc. (617-354-2339); www.daratech.com

**24-27 · NATPE 2000,** held in New Orleans. Contact: NATPE (310-453-4440); (fax: 310-453-5258); www.natpe.org

**27-30 · Medicine Meets Virtual Reality,** held in Newport Beach, CA. Contact: Aligned Management Associates Inc. (860-444-0362); (fax: 860-447-9767); www.amainc.com /MMVR/MMVR.html

**30-Feb 2 · Electronic Commerce 2000,** held in Orlando, FL. Contact: EC 2000 Conference Registrar (800-487-9180); (fax: 703-787-0996); www.nacha.org/conferences

**31-Feb 2 · Imagina,** conference held in Monaco. Contact: Imagina (tel: +377-93-15-93-94); (fax: +377-93-15-93-95); www.ina.fr /Imagina/99/Evenements/concours.en.html

### FEBRUARY

**2-4 · Imagina,** exhibition held in Paris. Contact: Imagina (tel: +377-93-15-93-94); (fax: +377-93-15-93-95); www.ina.fr/Imagina/99/ Evenements/concours.en.html

### MARCH

**7-9 · CAD/CAM/CAE Product Process Management Strategy Workshops 2000,** held in Boston. Contact: Daratech Inc. (617-354-2339); www.daratech.com

**10-12 · Game Developer's Conference,** held in San Jose, CA. Contact: GDC (415-905-2388); (fax: 415-905-2222); www.gdconf.com

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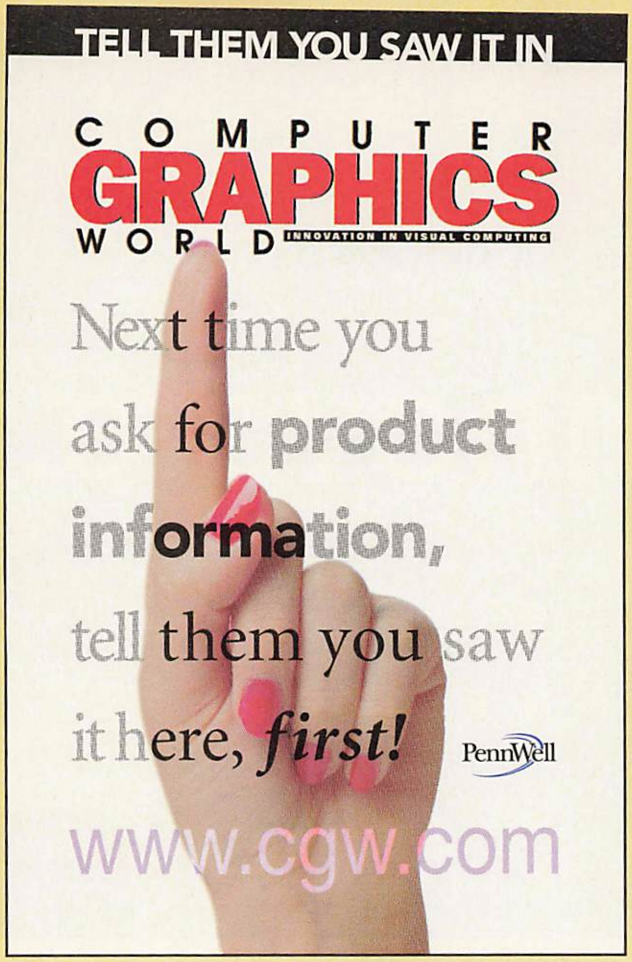

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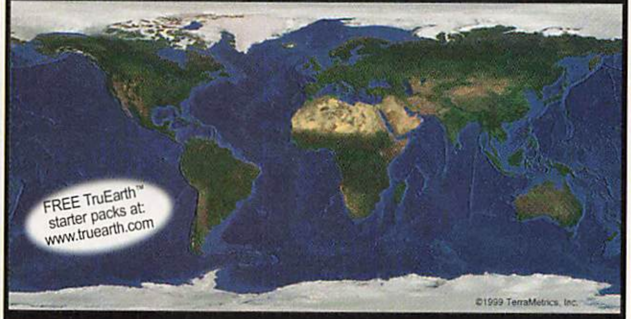

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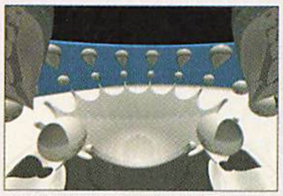

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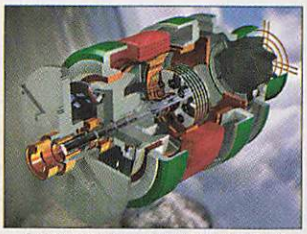

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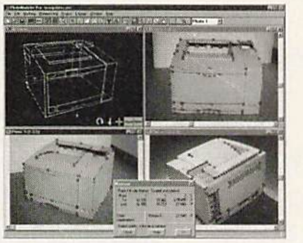

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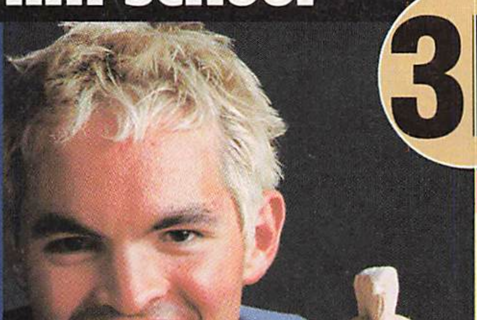

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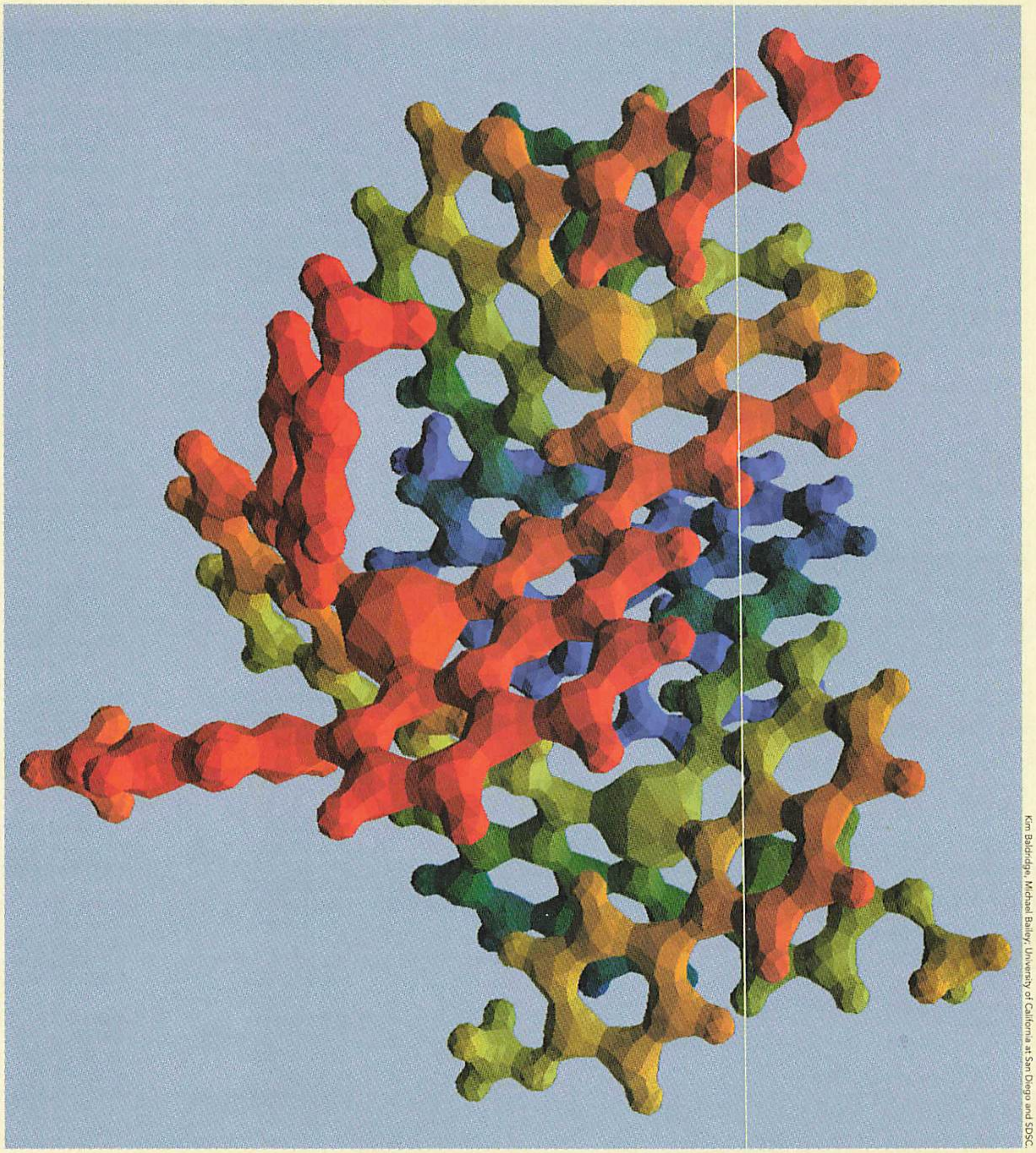

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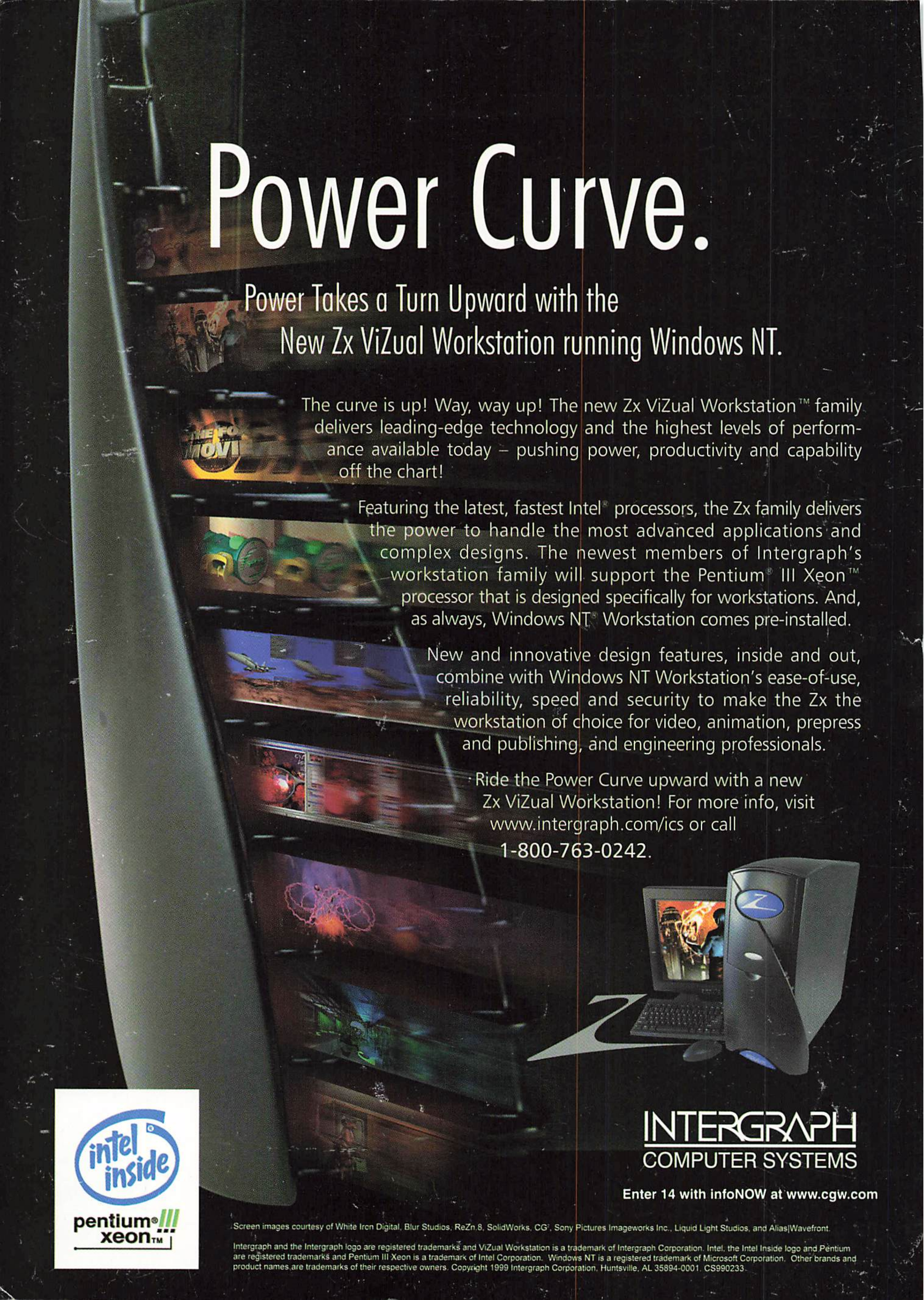

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